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Title: Working on Mars with Rovers

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Working on Mars with Rovers

Location and date

R. Beal, N. Lanza

Brought to you by:

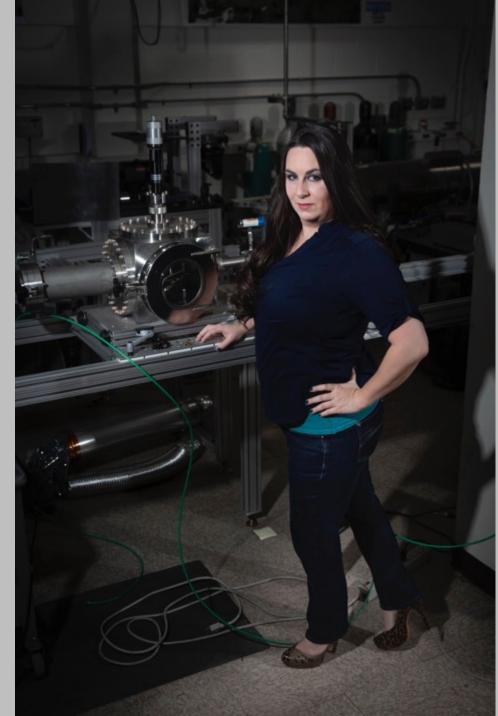












Outline

Day1:

- 1. My path to mars
- 2. Mars facts
- 3. Curiosity Rover
- 4. ChemCam Instrument
- 5. Rover operations

Day 2:

- 1. Results from ChemCam
- 2. Challenges for ChemCam
- 3. Perseverance Rover
- 4. SuperCam Instrument
- 5. Activity!
- 6. Memes

Day 3: Visit me in the councilor's office!



About me: Space is for everyone!

We don't all look the same or come from the same background! We are all different and it is our diversity that makes missions great!

For example, your presenter is:

- On a non-traditional career path
 - HS-> Navy -> in and out of college->
 a few STEM jobs -> mars missions
- On a mostly woman identifying engineering team
- A product of the foster system
- A veteran
- LGBTQ+ identifying
- A single mother
- Not a PhD recipient
- Neurodiverse: Autistic/ ADHD







Current events from my year book that shaped my career

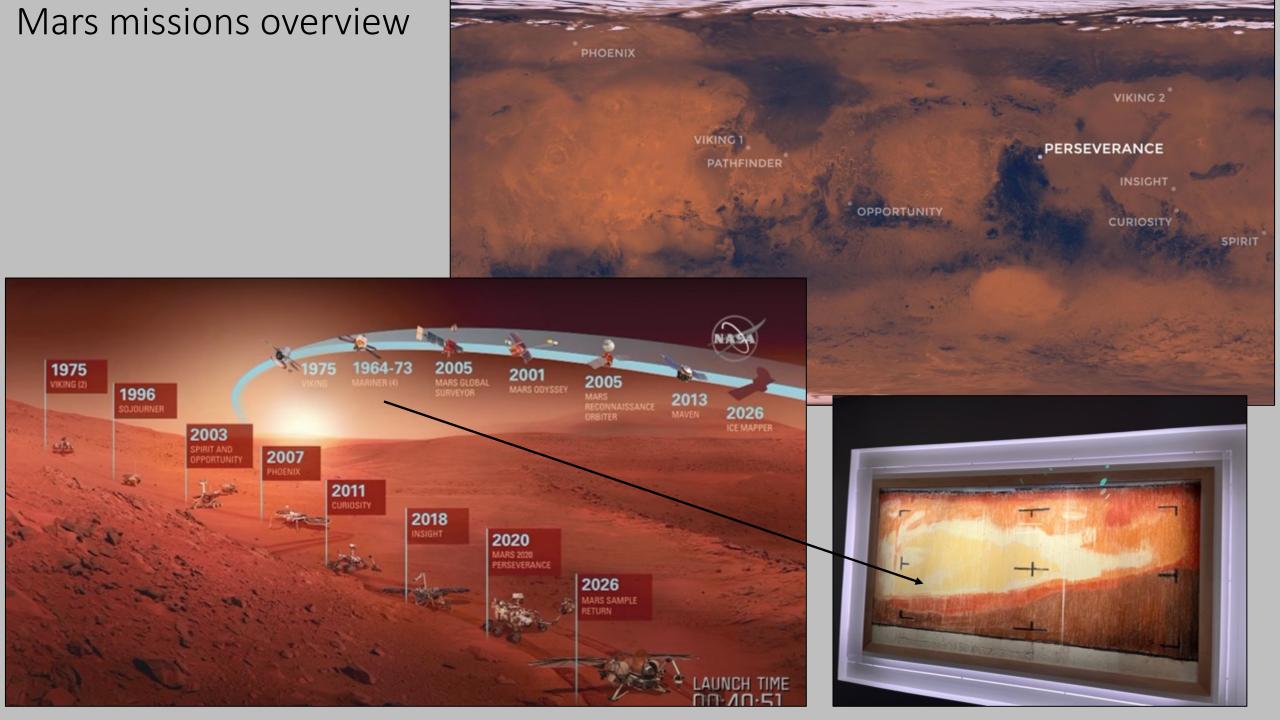
The Mars Polar Lander was launched from Cape Canaveral on January 3, 1999. Its 470 million-mile journey will conclude on December 3, 1999, with arrival in Martian orbit. Then, the lander will deploy two probes which will penetrate several feet into the polar surface and send back data on the geology and water/ice presence in the subsurface strata.



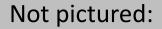
The Mars
Surveyor Trolley,
named Sojourner, is
carried on-board
Mars Pathfinder, an
unmanned spacecraft
launched in December.
Sojourner, a free-roving
probe the size of a
child's wagon, will
photograph the Martian
surface and determine
the composition of
rocks on Mars.



Earth vs Mars	Earth	Mars	
Atmosphere composition	Mostly oxygen and nitrogen, thick and breathable	Carbon Dioxide, very thin, not breathable	Phobos and Deimos
Average temperature	58.62 F (14.9 C)	-80 F (-60 C)	Olympus Mons
Ozone layer	Yes	No	
Magnetic field	Yes	No	
Inhabitants	More than robots	robots	Mauna Loa Everest
Volcanoes	Yes	Yes: Olympus Mons is the largest volcano in the Solar System!	Mountain range size comparison https://www.reddit.com/r/Damnthatsinteresting/comments/qs00g4/olympus_mons_mauna_loa_and_mt_ever est_compared/
Canyons	Grand Canyon: spreads across Arizona, USA	Valles Marineris: Length of the continental United States	
One rotation around its axis	Day: 24 hours	Sol: 24 h: 39m: 35s	
Year	365 days	687 days	
Moons	1: the moon	2: Phobos and Deimos	Valles Marineris size comparison

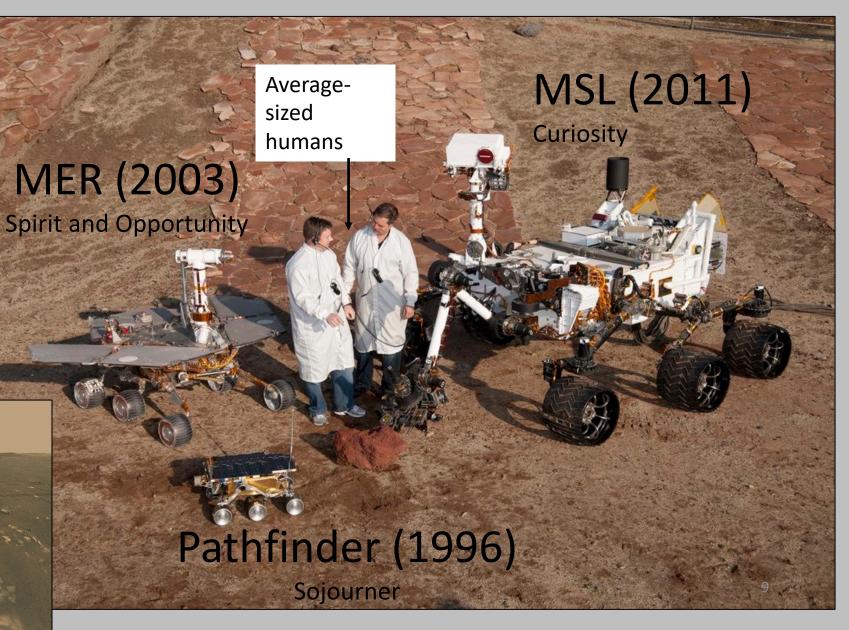


Mars rover family



M2020 (2020)

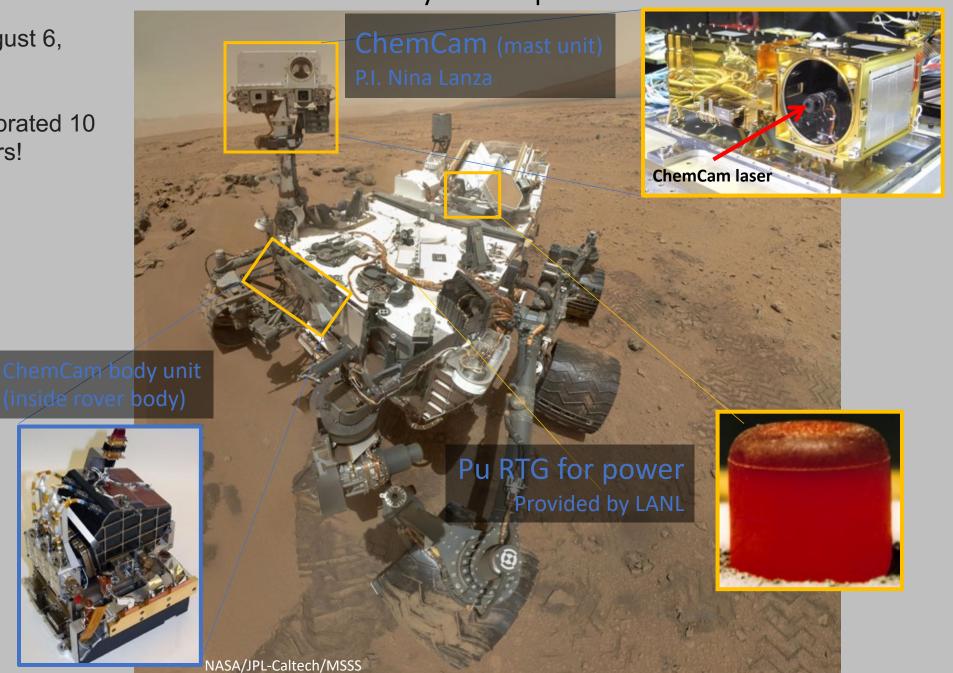
Perseverance (Slightly larger than Curiosity)



Curiosity: components

Landing: August 6, 2012

We just celebrated 10 years on mars!



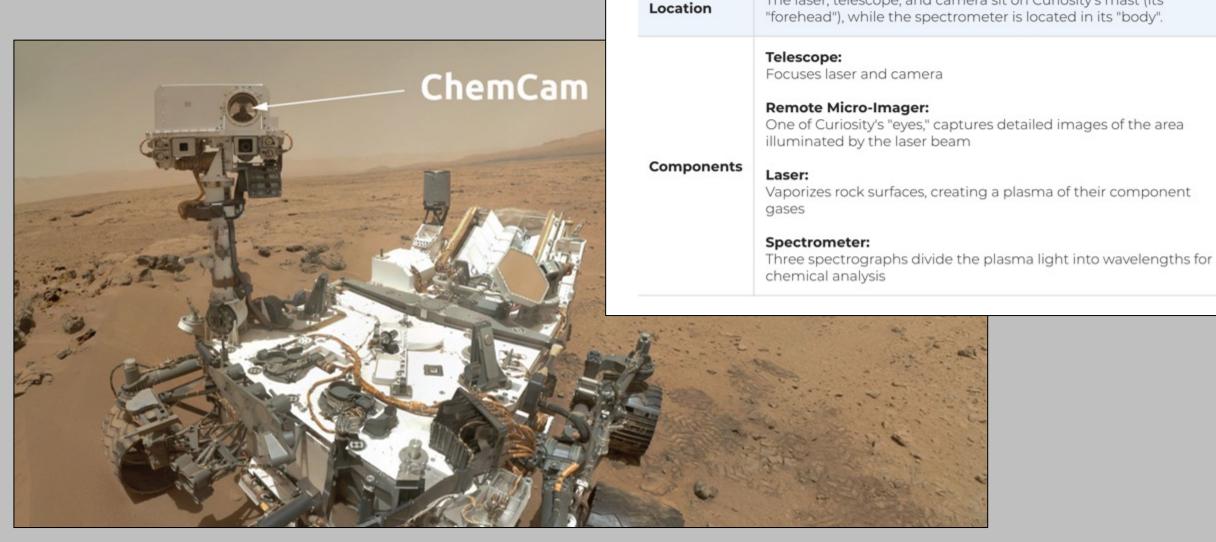
To analyze the chemical composition of rocks and soil.

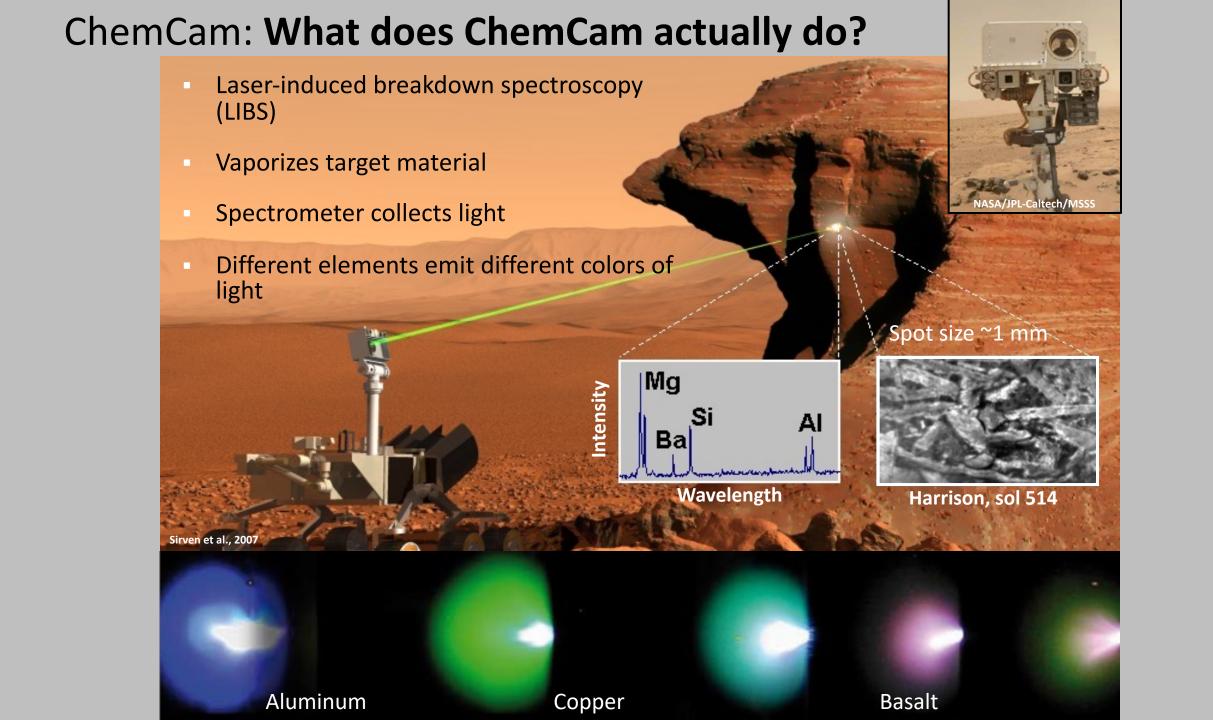
The laser, telescope, and camera sit on Curiosity's mast (its

Tech Specs

Main Job

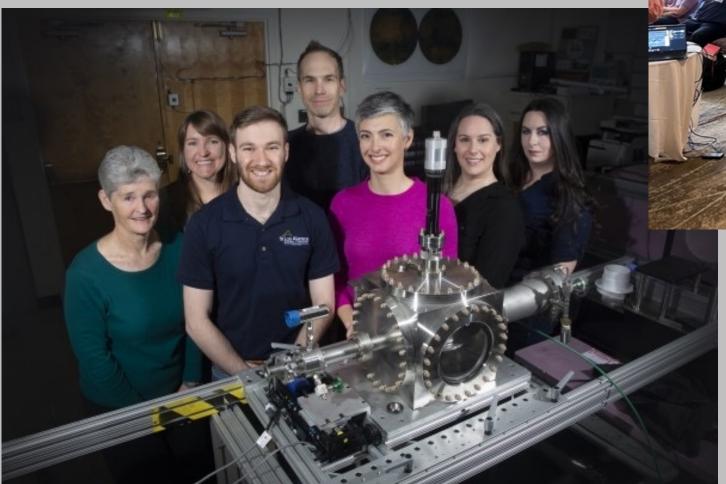
ChemCam





ChemCam team Oct 2022

ChemCam is an international collaboration!





- Joined in 2019
 - But was previously involved with the mission in grad school
- US operations manager

Goals of Curiosity

To assess the past and present habitability of the martian environment

- Not a search for life per se
- Environments in which life could exist
 - H₂O (key criterion for life)
 - Hydrated and water-formed minerals
 - Organic materials
 - Surface radiation environment



Curiosity: What can we look for?

Life Needs

- Liquid water
 - Temperature range
 - pH → acidic versus basic
- Energy source
 - Food (minerals)
 - Light (photosynthesis)
- Chemical building blocks
 - C, H, N, O, P, S
- Protection from UV, other radiation (but not always)

Life Produces

- Shapes and patterns
 - Fossilized bones, tissues
 - Burrows, tunnels, nests, etc
- Atmospheric gasses
 - Oxygen (O₂)
 - Methane (CH₄) (natural gas)
- Minerals and rocks
 - Limestone
 - Oil (shale)

We can look for all of the above on Mars with Curiosity

ChemCam: What can ChemCam detect?

Life Needs

- <u>Liquid water</u>
 - Temperature range
 - pH → acidic versus basic
- Énergy source
 - Food (minerals)
 - Light (photosynthesis)
- Chemical building blocks
 - C, H, N, O, P, S
- Protection from UV, other radiation (but not always)

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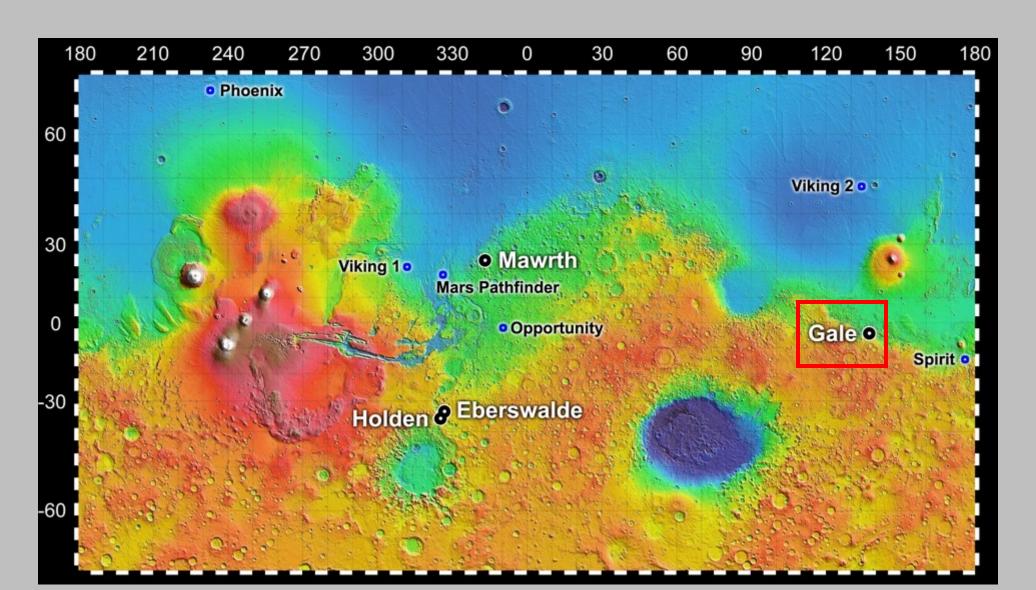
ChemCam can help us find many signs of habitability

Curiosity: Why aren't we looking for life directly?

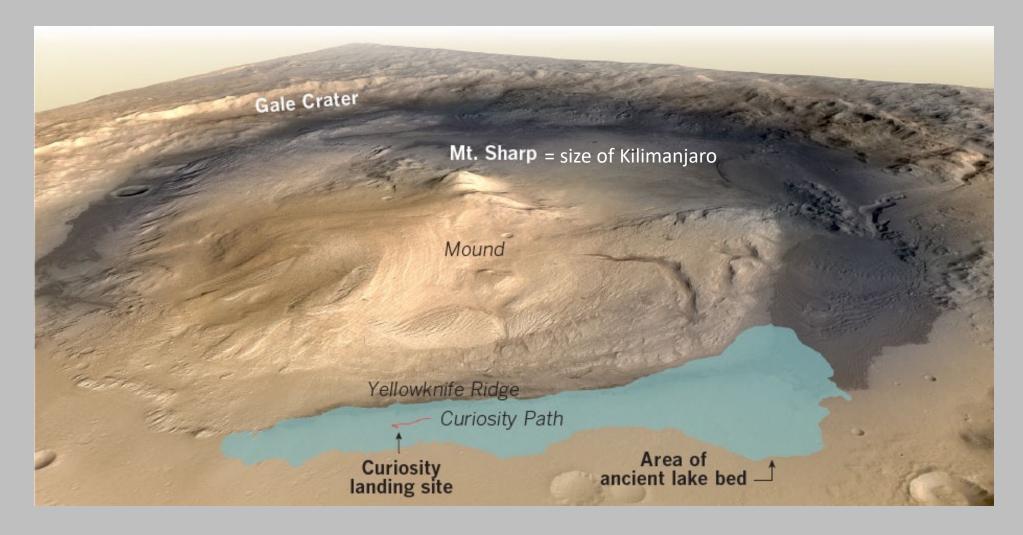
- Difficult to confirm
 - How do we know when we've found it?
- Understanding habitability is more straightforward > prerequisites for life



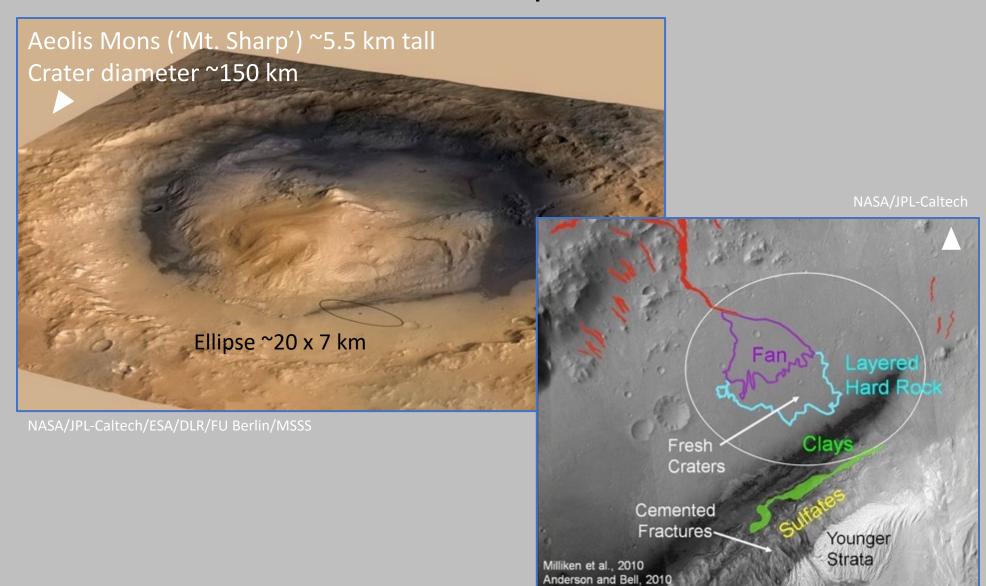
Curiosity: Landing site-Gale Crater



An ancient lake bed?

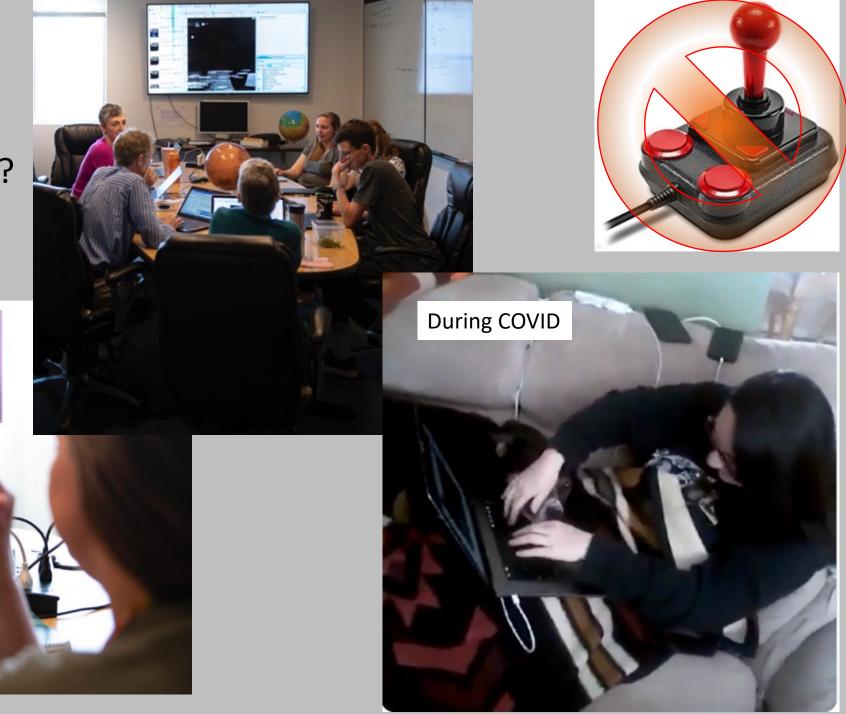


Gale crater and Mt. Sharp

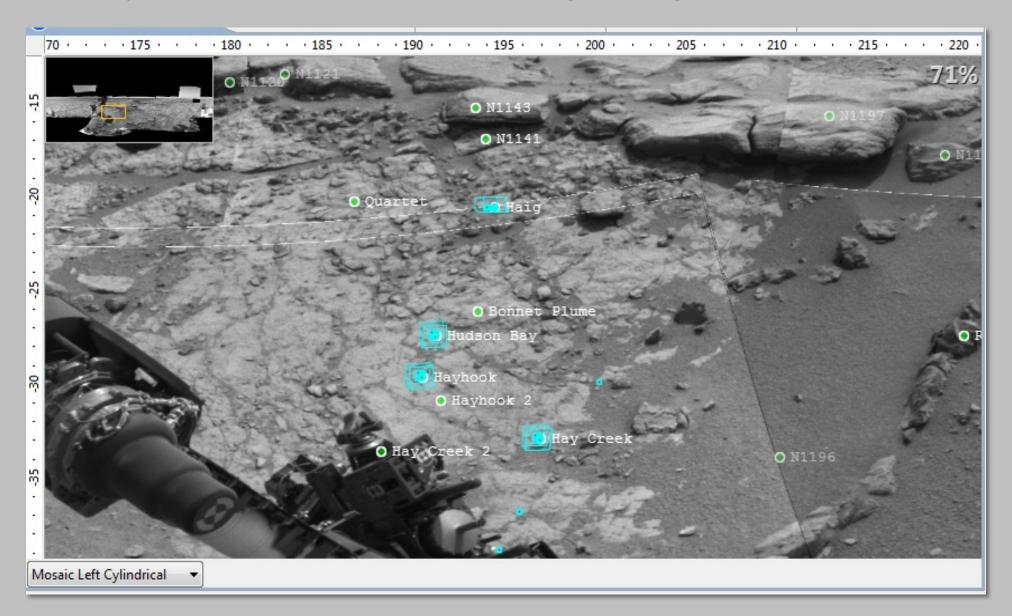


Operations

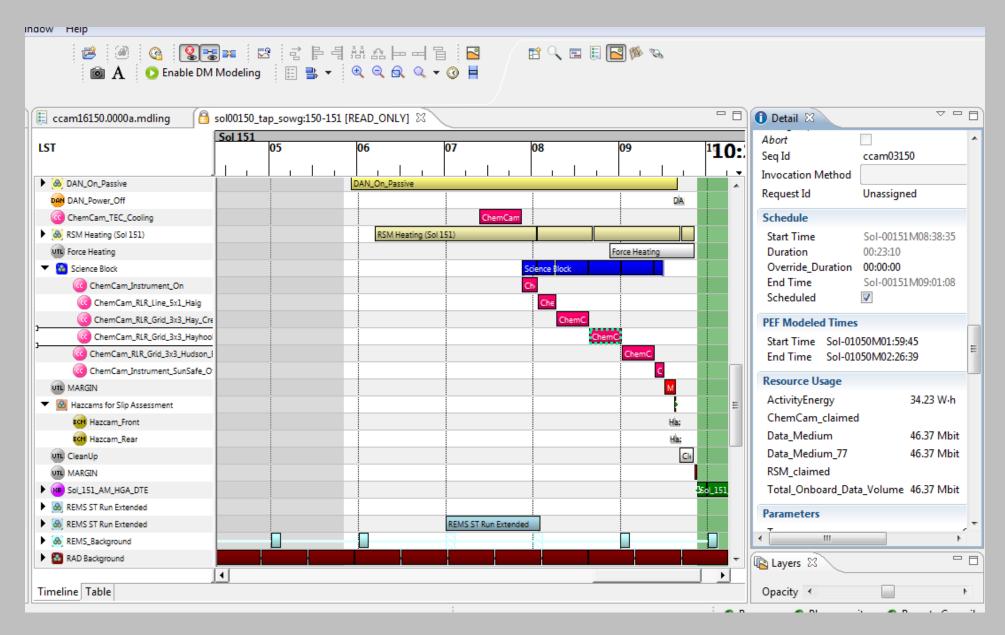
How do we "drive" rovers?
.. From our laptops!



Operations: Selecting targets



Operations: Planning activities



Operations: How do we talk to mars?

At 256 kbit/s:



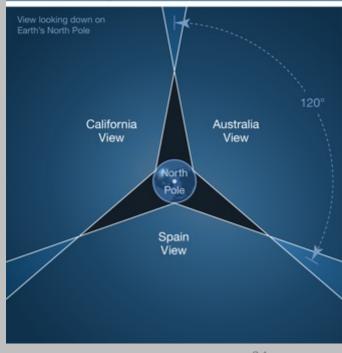


https://www.youtube.com/watch?v=6WFj-CKldv4
(End at 34 seconds)

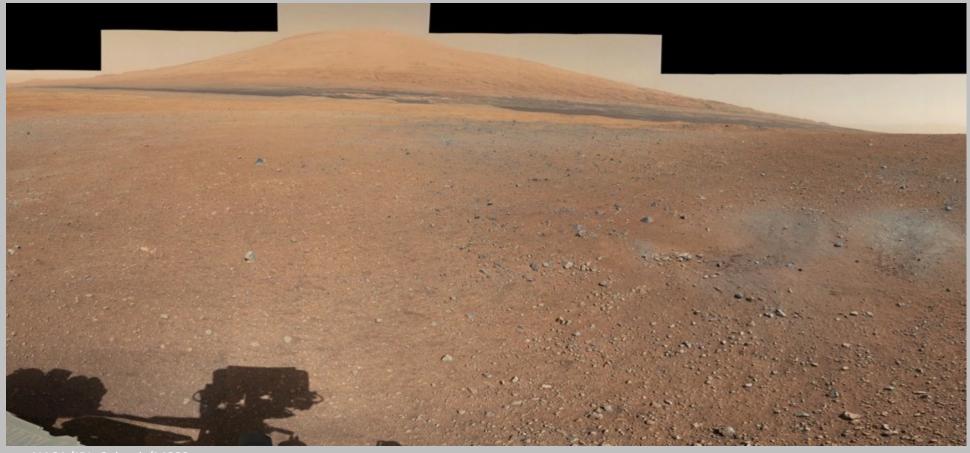
DSN real time: https://eyes.nasa.gov/dsn/dsn.html





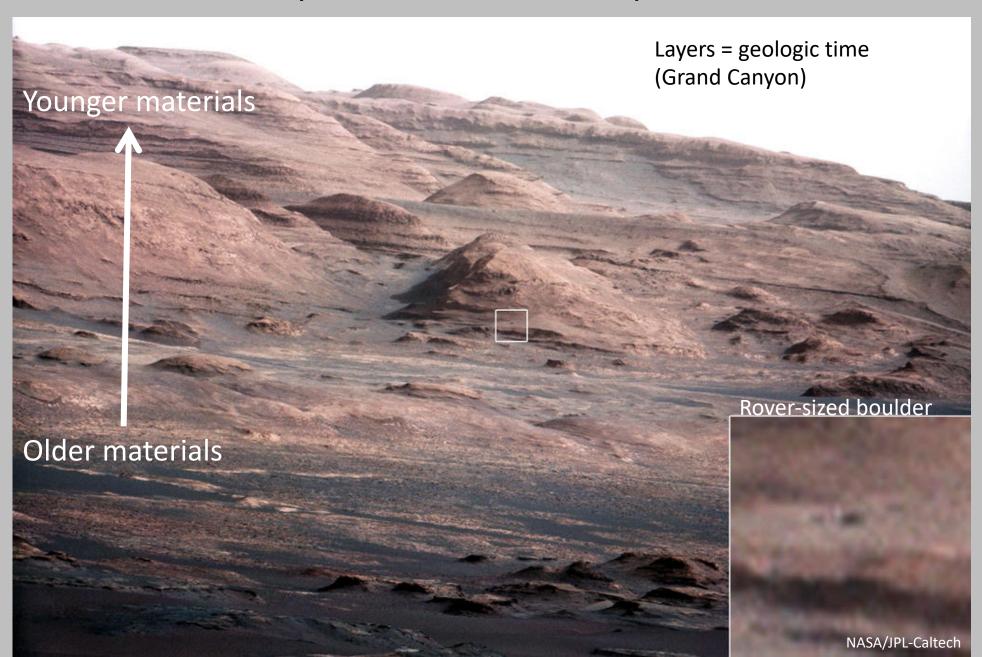


Results: View of Mt. Sharp from landing site MastCam image



NASA/JPL-Caltech/MSSS

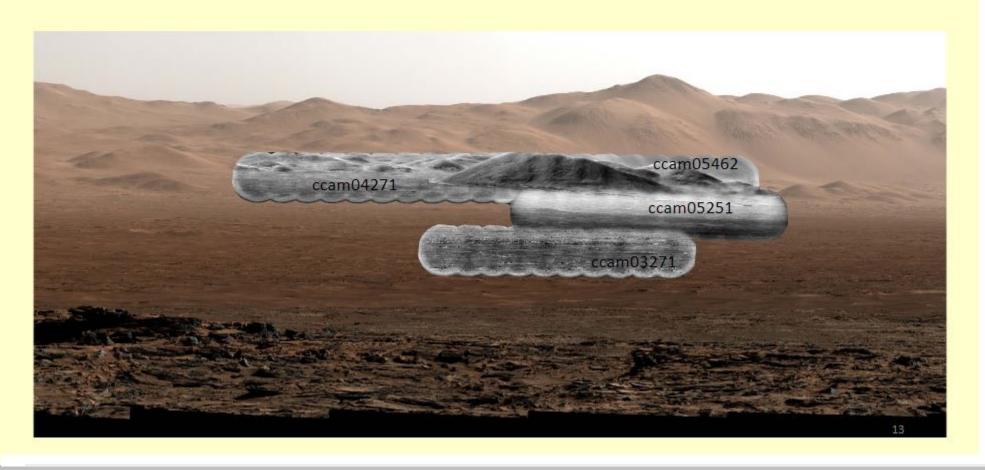
Results: Layers of Mt. Sharp





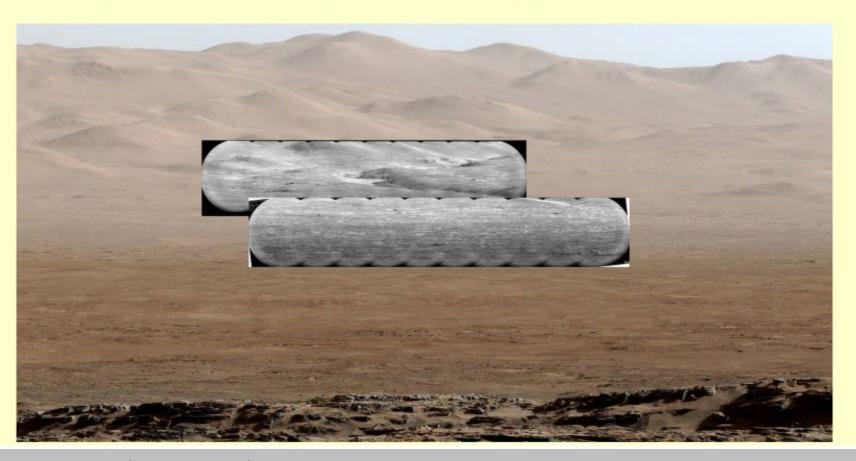


Context – Peace Vallis Fan – eroded face, fan structure

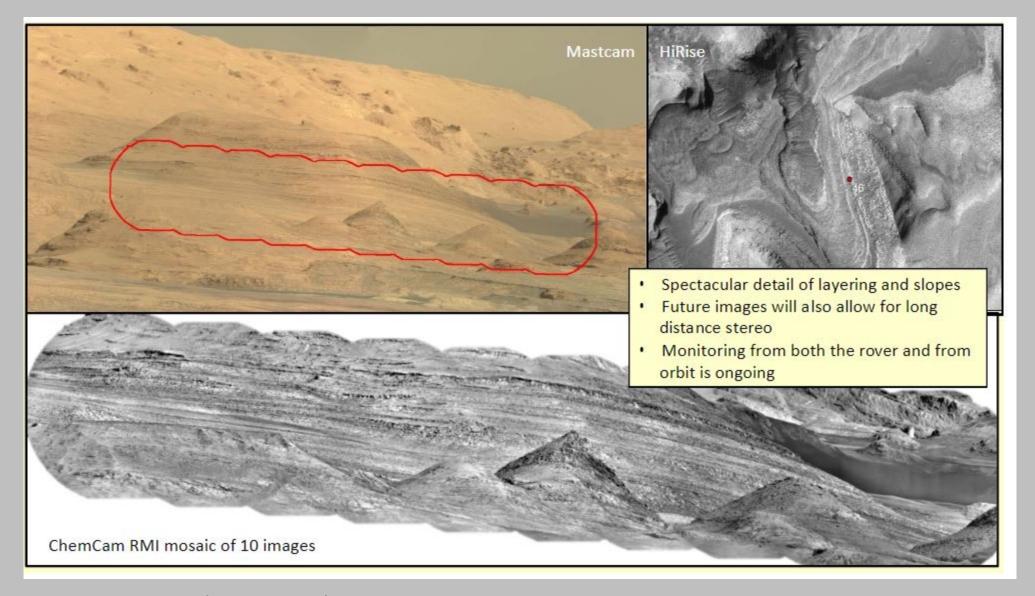


https://www.researchgate.net/publication/309337486_LONG_DISTANCE_OBSERVATIONS_WITH_THE_CHEMCAM_REMOTE_MICRO-IMAGER_MOUNT_SHARP_AND_RELATED_SEDIMENTARY_DEPOSITS_ON_GALE_CRATER_FLOOR

Peace Vallis Fan head channel with two superimposed 10 image RMI mosaics (~25 km range)



https://www.researchgate.net/publication/309337486_LONG_DISTANCE_OBSERVATIONS_WITH_THE_CHEMCAM_REMOTE_MICRO-IMAGER_MOUNT_SHARP_AND_RELATED_SEDIMENTARY_DEPOSITS_ON_GALE_CRATER_FLOOR



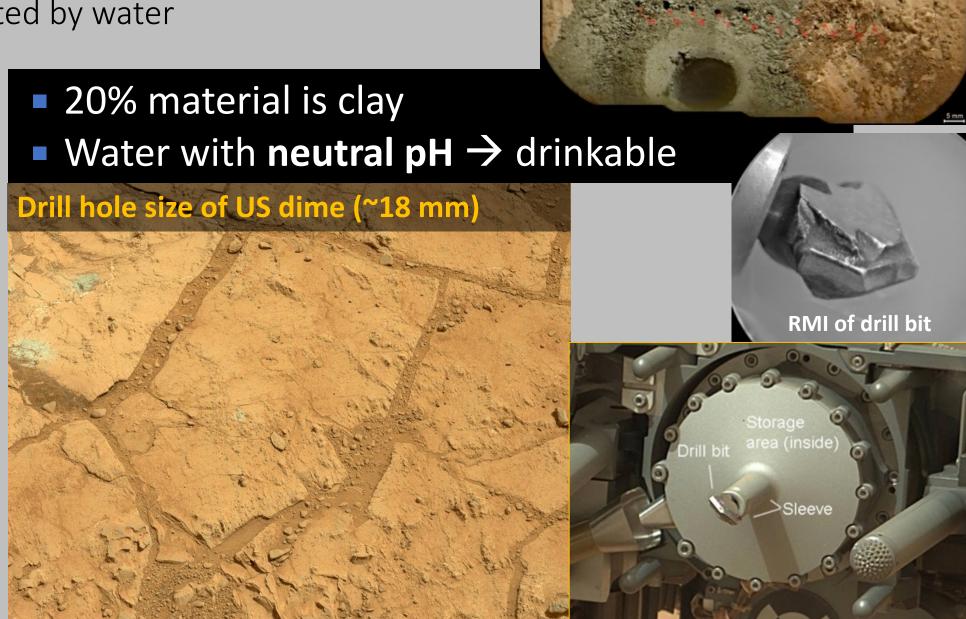
https://www.researchgate.net/publication/309337486_LONG_DISTANCE_OBSERVATIONS_WITH_THE_CHEMCAM_REMOTE_MICRO-IMAGER_MOUNT_SHARP_AND_RELATED_SEDIMENTARY_DEPOSITS_ON_GALE_CRATER_FLOOR

Results: Conglomerate rock



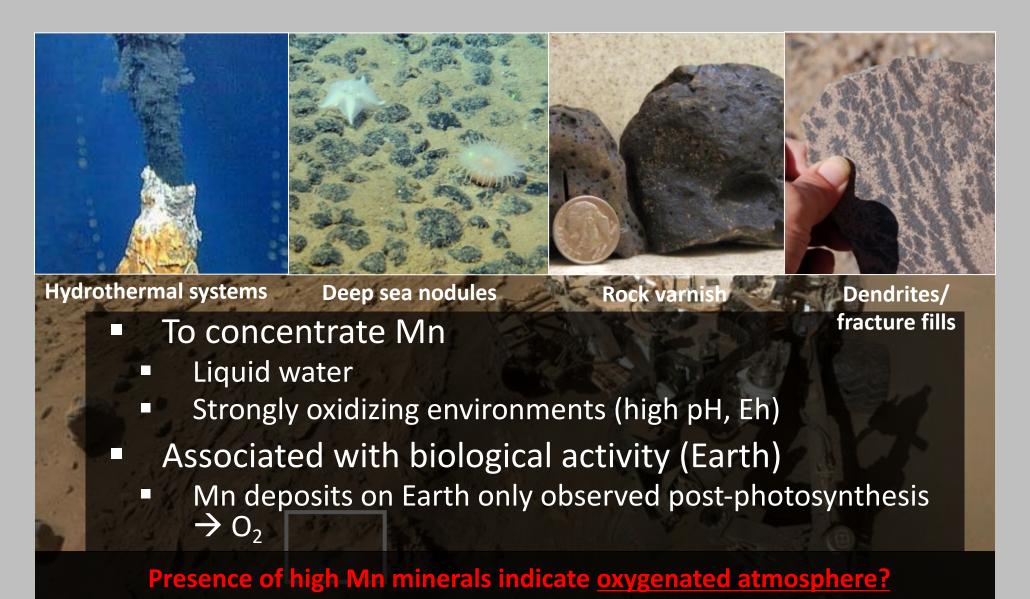
Results: Clay

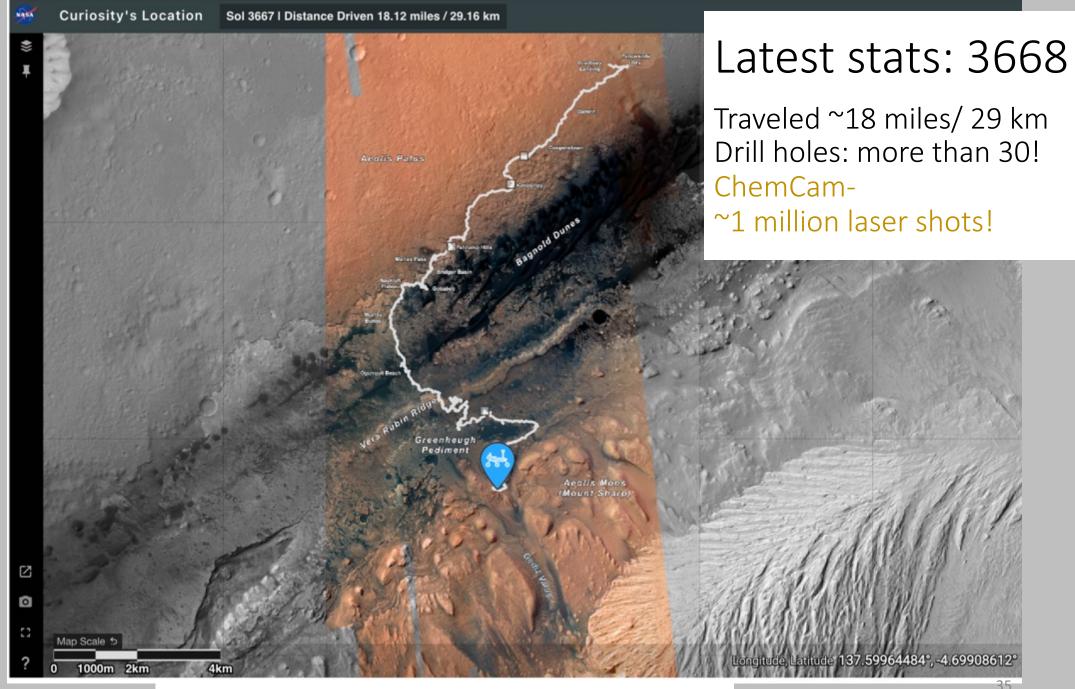
Deposited by water



Results: High concentrations of Mn

Strongly oxidizing, aqueous conditions





https://mars.nasa.gov/msl/mission/where-is-the-rover/

Challenges: Terrain





Challenges: Causes and solutions

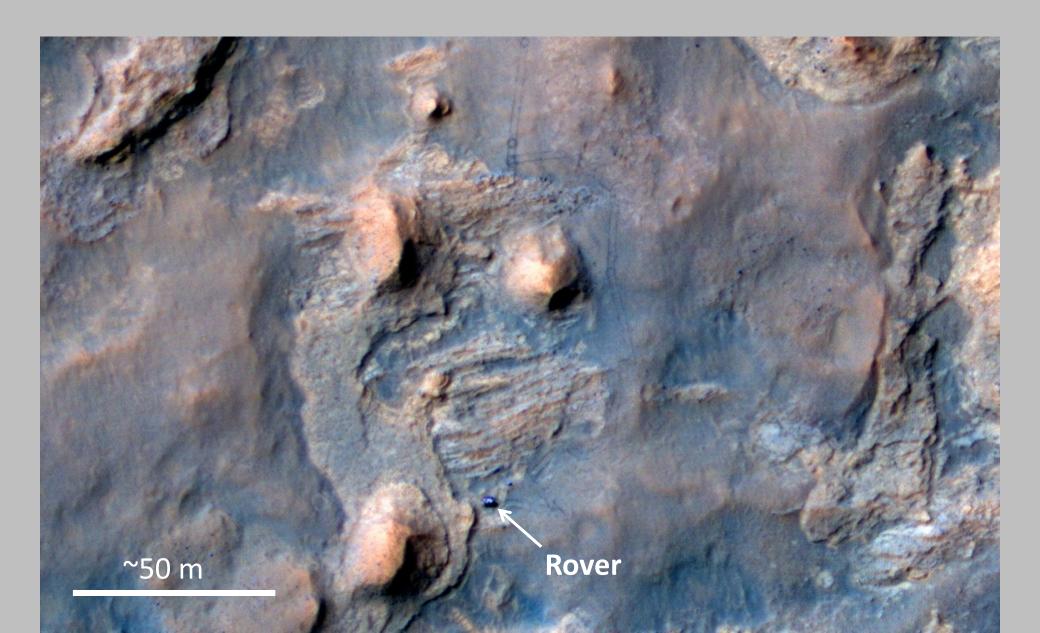
- differential par
- Mars rocks are ventifacted (wind-faceted)
 - Harder materials at Gale
- Rocker-bogie system
 - Keeps rover body at low pitch/tilt
 - Greatest load on front, middle wheels
 - Wheels are Al rather than Ti
- Solutions
 - Drive backward
 - Plan traverse to avoid rocks
 - Treat wheels as limited resource



http://www.2zmtns.com/califor nia_01.html

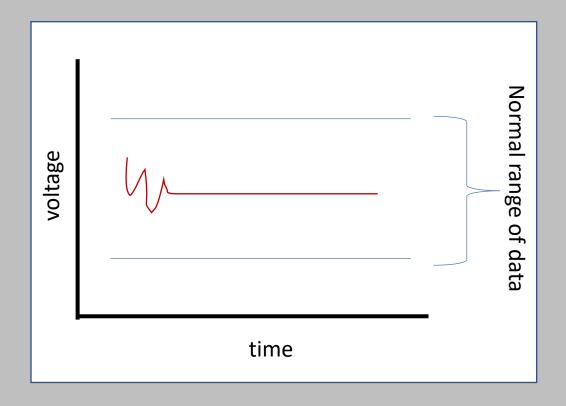
Can't easily predict local Mars environments!

Solutions: Traverse planning with HiRISE

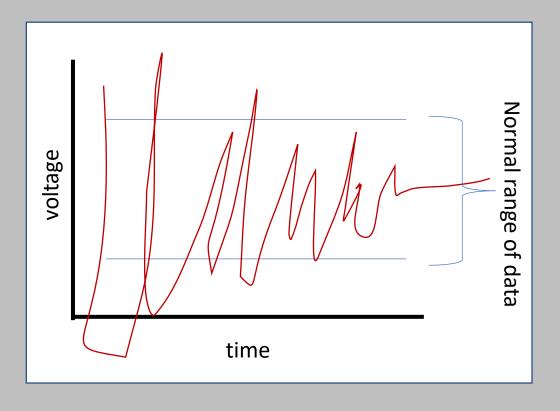


Challenges: ChemCam Laser anomaly

Normal laser behavior



Abnormal laser behavior



What happened?

How did we "fix" it?

New challenge: What's this rock?

Chemistry versus mineralogy

- Rocks = specific mineral assemblages
- Minerals = structure + chemistry

CaCO₃



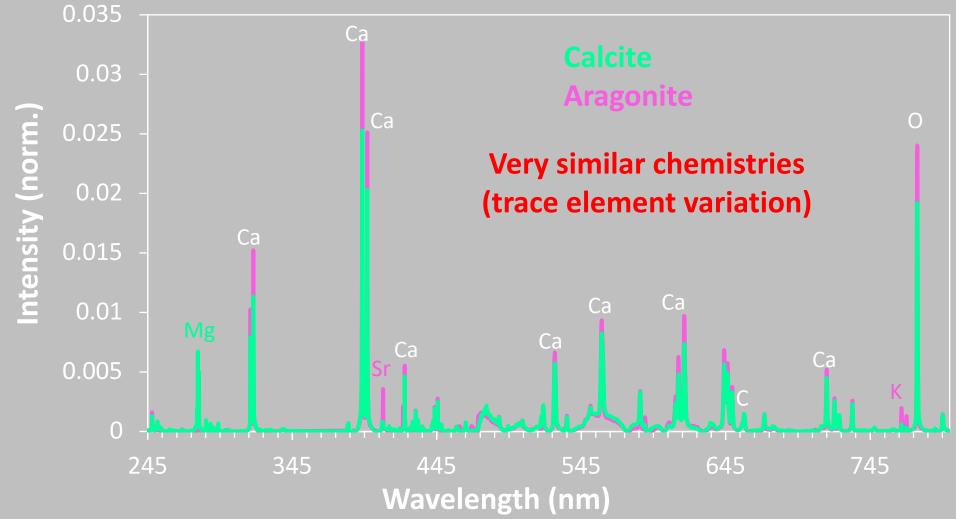
Need both chemistry and mineralogy to ID

Challenge: LIBS

CaCO₃ (6 mbar CO₂)





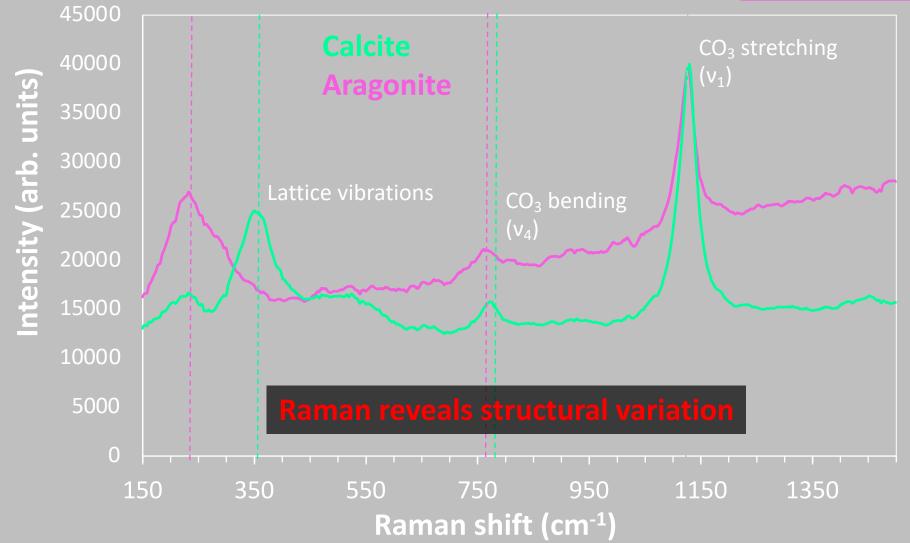


Solution: Raman

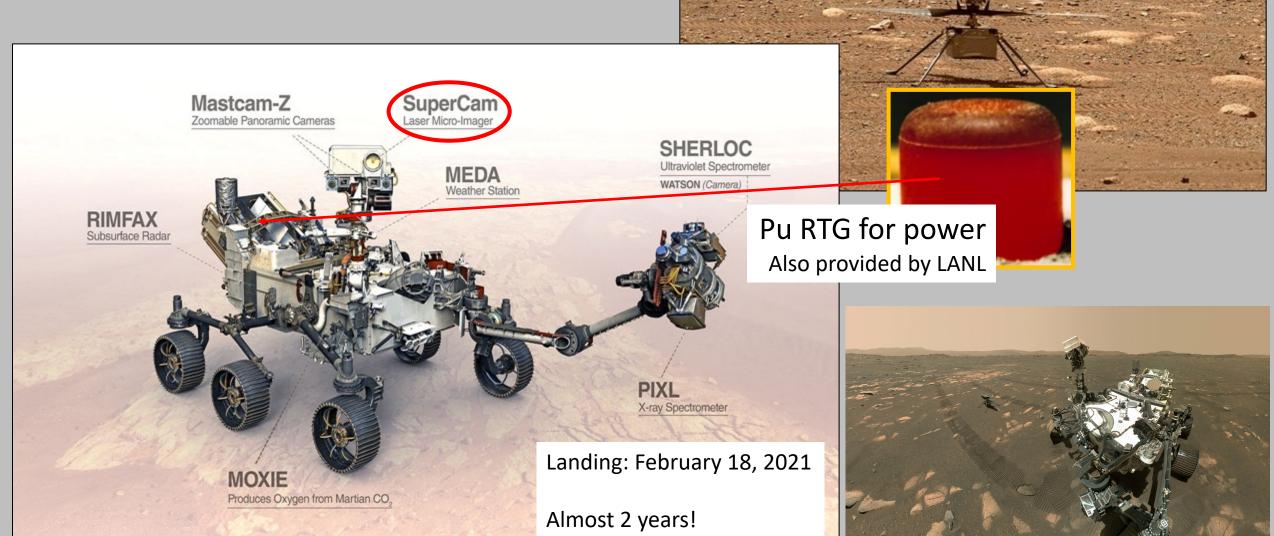
CaCO₃ (lab atm)







Perseverance Rover and Ingenuity helicopter



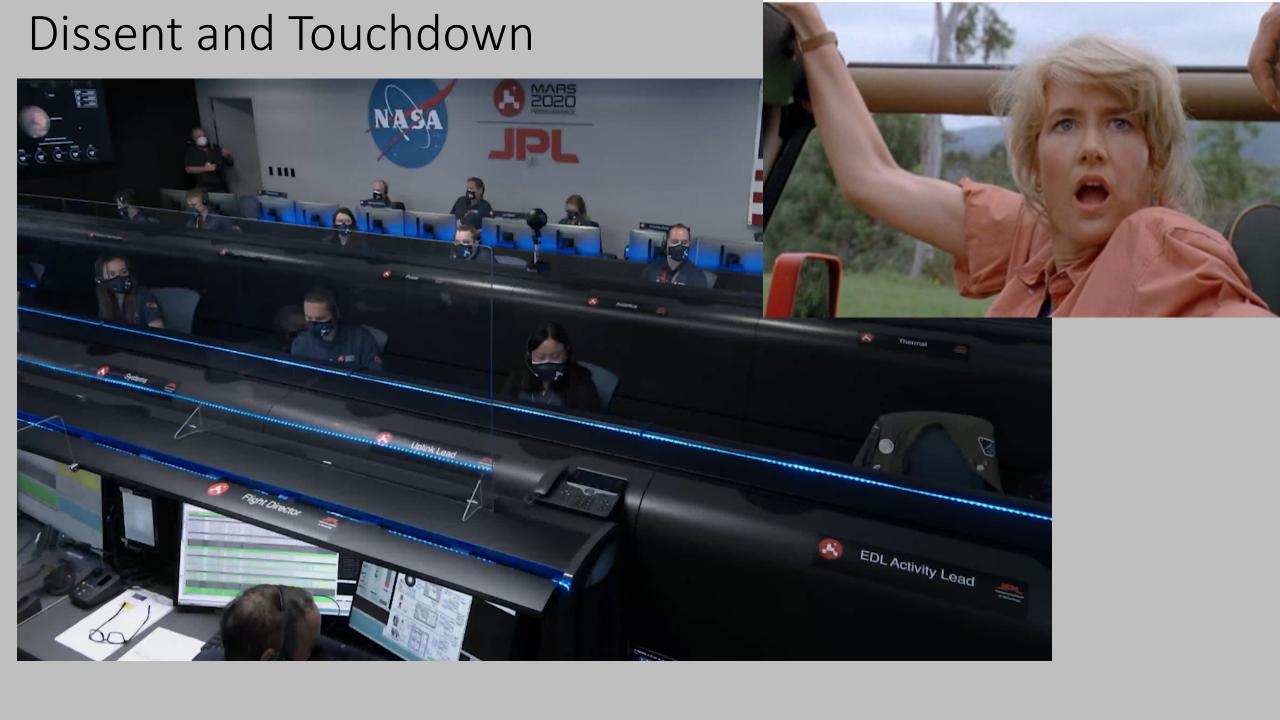
Ingenuity

Goals of Perseverance

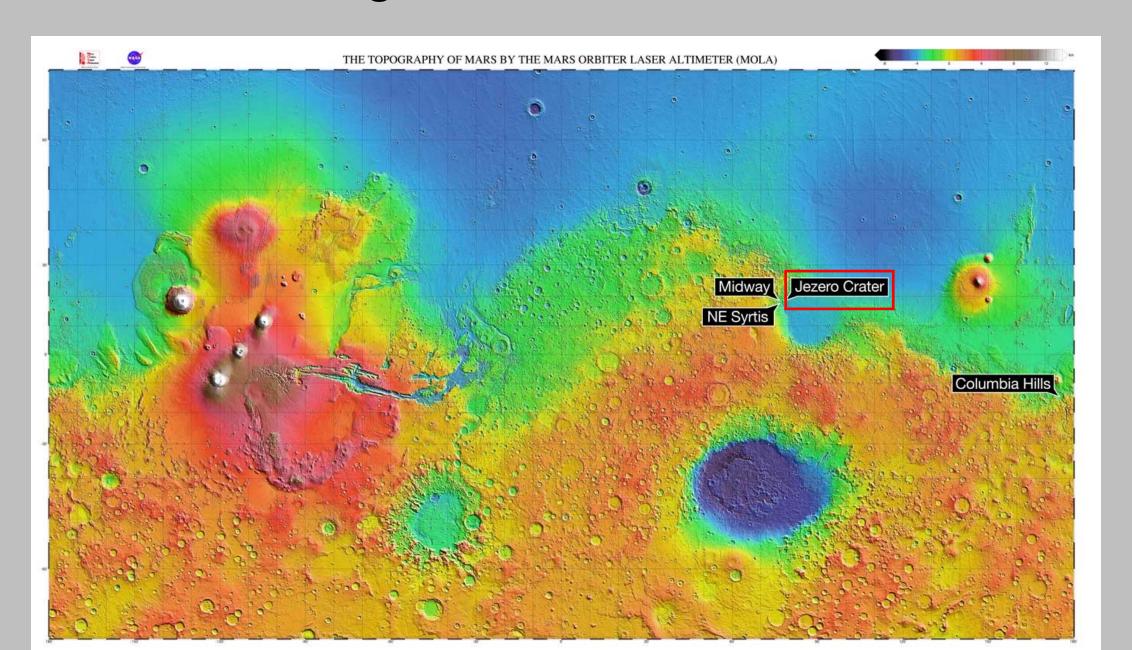
Perseverance is searching for signs of past and present life on Mars, as well as testing out new technologies to aid future human missions to Mars.



- 1. Determine whether life ever existed on Mars
- 2. Characterize the climate of Mars
- **✓** 3. Characterize the geology of Mars
- ✓ 4. Prepare for human exploration of Mars



Perseverance Landing site: Jezero Crater



Perseverance landing site from HiRISE Descent Parachute & Back Shell Stage Perseverance

SuperCam



Tech Specs

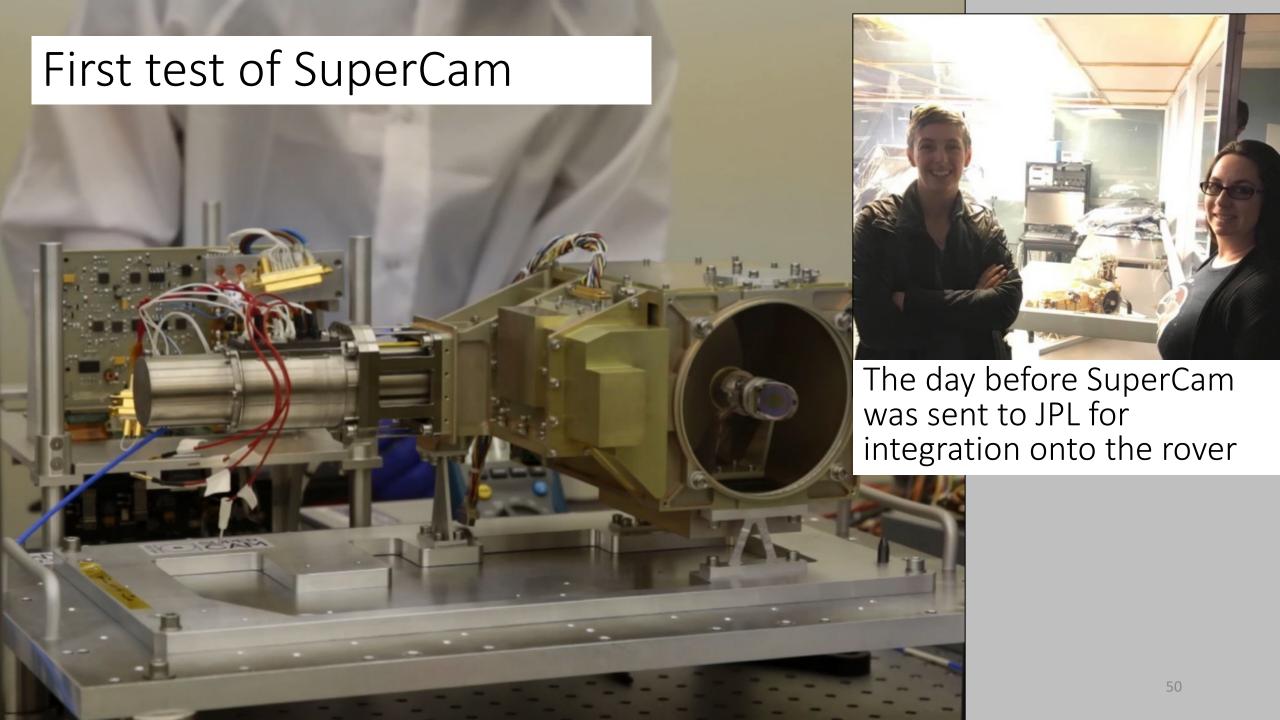
rech Specs	
Main Job	To identify the chemical composition of rocks and soils, including their atomic and molecular makeup
Location	Mounted on the "head" of the rover's long-necked mast
Mass	Mast-mounted sensor head: 12 pounds (5.6 kilograms) Rover body-mounted electronics: 10.6 pounds (4.8 kilograms) Calibration target: 0.5 pound (0.2 kilograms)
Power	17.9 watts
Volume	Mast-mounted sensor head: approximately 15 by 9 by 8 inches (38 by 24 by 19 centimeters)
Calibration Target	1.18 inches diameter (3 centimeters)
Data Return	15.5 megabits per experiment or about 4.2 megabits per day

I joined the team a few months before launch in summer of 2020

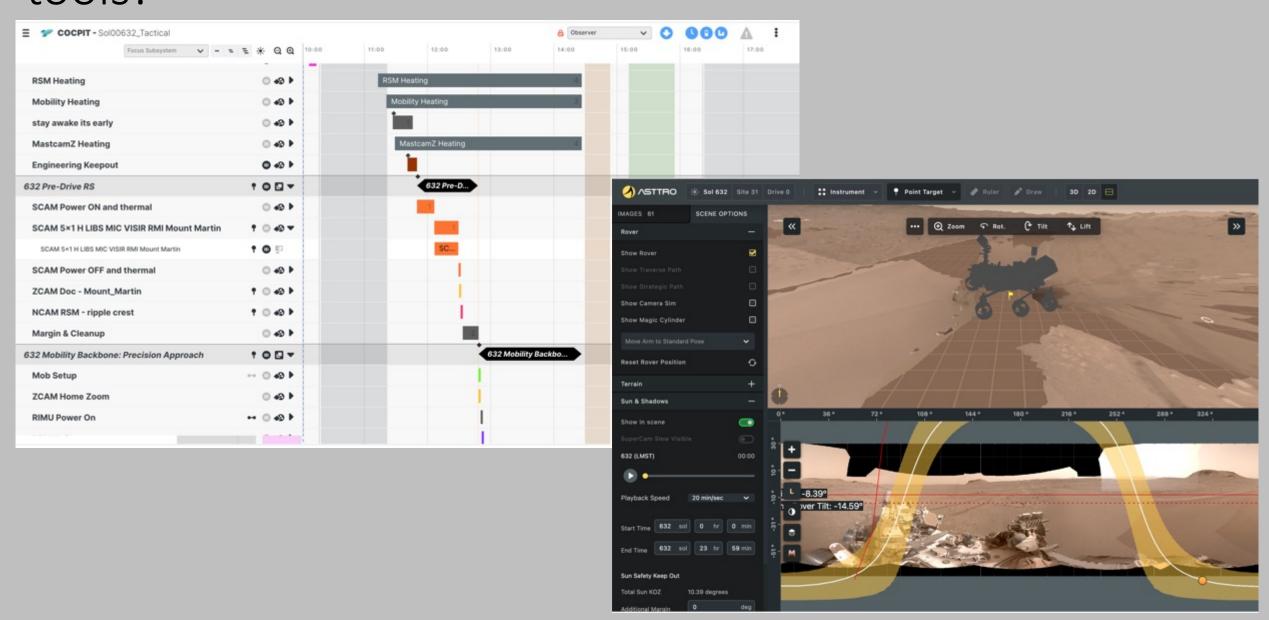


Key improvements from ChemCam:

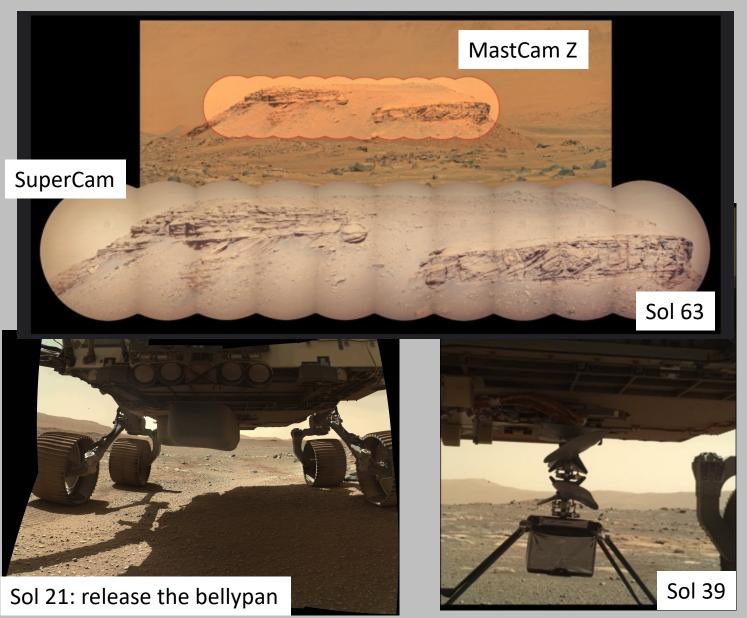
- Color RMI
- Raman
- VISIR
- Microphone

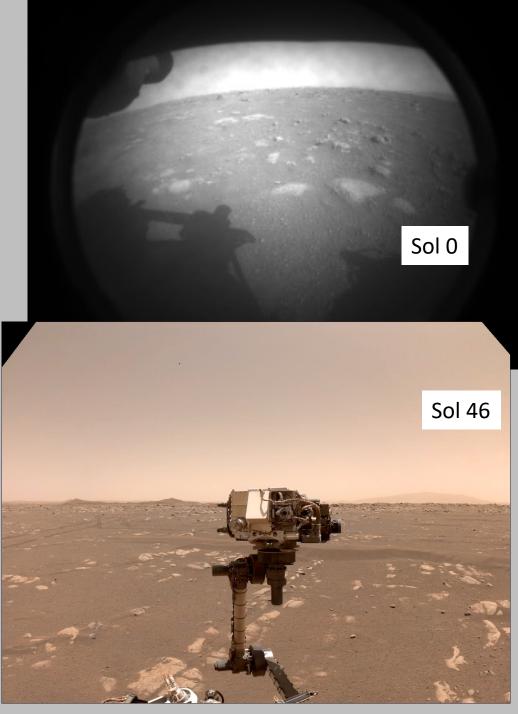


Operations: similar to ChemCam, but with newer, fancier tools!



First 90 sols: mars time

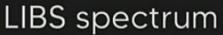


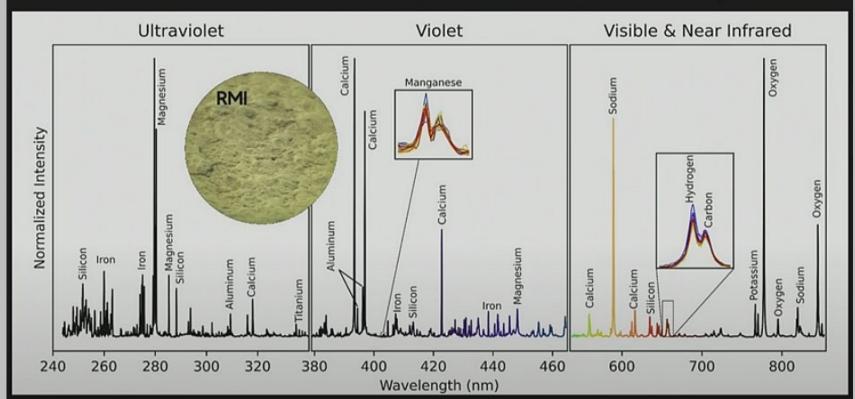


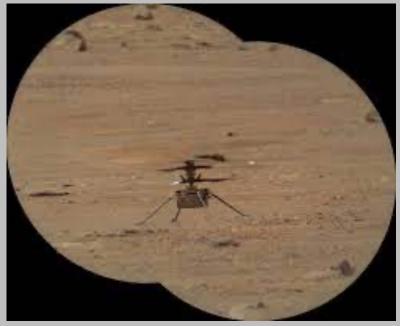
Results: SuperCam data and images



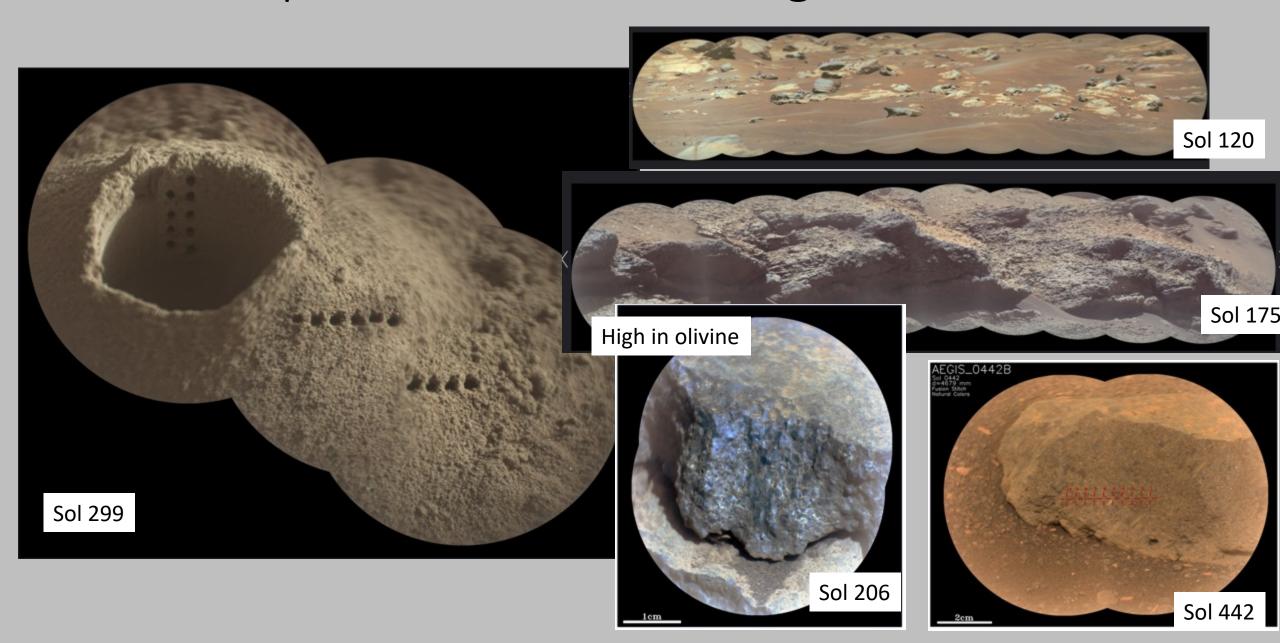
Maaz target (Sol 12)







Results: SuperCam data and images



Results: Sounds

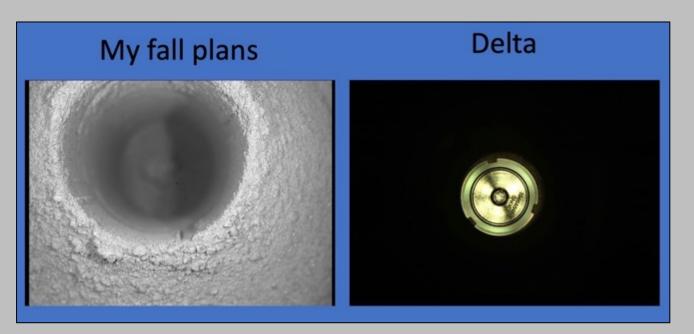
• https://www.jpl.nasa.gov/videos/nasas-perseverance-rover-captures-the-sounds-of-mars

Spoiler alert: the laser does not make pew pew pew pew pew noises

Where is Perseverance? Latest stats: sol 633 Traveled ~8 miles/ 13 km 15 rock cores collected ~34 Ingenuity flights Latest Drive: Sol 632 | Total Distance 8.29 miles / 13.34 km SuperCam-LIBS: over 100,000 Raman: over 100,000 Longitude, Latitude 77:37507820°, 18.44518803°

https://mars.nasa.gov/mars2020/mission/where-is-the-rover/

Challenges





Solution from previous mission:



Illustrated here, the aluminum wheels of NASA's Curiosity (left) and Perseverance rovers. Slightly larger in diameter and narrower, 20.7 inches (52.6 centimeters) versus 20 inches (50.8 centimeters), Perseverance's wheels have twice as many treads, and are gently curved instead of chevron-patterned. Credit: NASA/JPL-Caltech

+Larger view

Follow along at home!

- DSN: https://eyes.nasa.gov/dsn/dsn.html
- Curiosity raw images:

 https://mars.nasa.gov/msl/multimedia/raw-images/?order=sol+desc%2Cinstrument_sort+asc%2Csample_type_sort+asc%2C+date_taken+desc&per_page=50&page=0&mission=msl
- Where is Curiosity? https://mars.nasa.gov/msl/mission/where-is-the-rover/
- Perseverance raw images: <u>https://mars.nasa.gov/mars2020/multimedia/raw-images/</u>
- Where is Perseverance? https://mars.nasa.gov/mars2020/mission/whe re-is-the-rover/
- Social media, nasa.gov

Suggested reading/watching:

- Goodnight Oppy
- Built for Mars: the Perseverance Rover
- Any episode of How the Universe Works
- Our Nature paper:
 - In situ recording of Mars soundscape

How can *you* get here?

Or wherever you want to be

Step 1: You don't have to be "good," you just have to love it

- Experts = ~10,000 h of practice (5 years)
- You can learn anything if you put in the time

Remember...research is about answering questions that **no one** knows the answer to

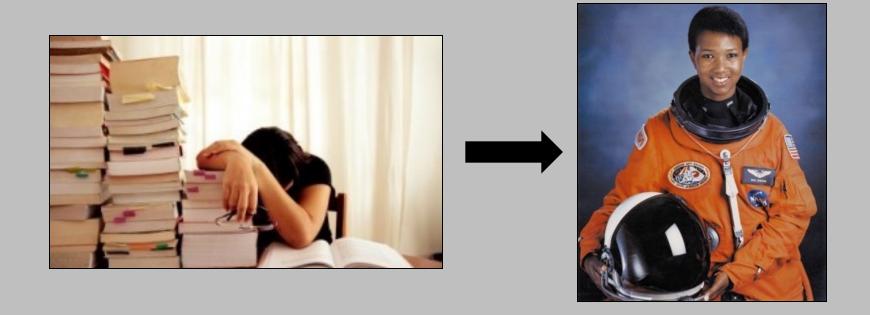
- You aren't dumb if you don't know the answer!
- Can be good at research and not school

How can *you* get here?

Or wherever you want to be

Step 2: Don't limit yourself to things that are easy

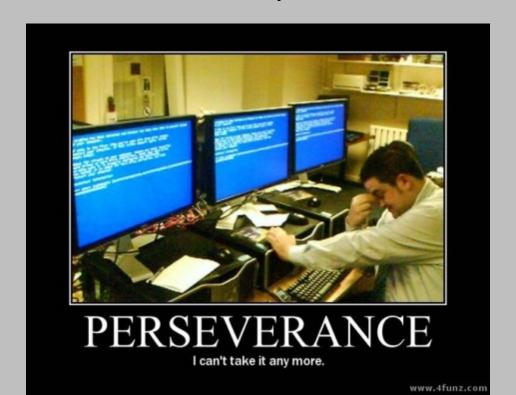
- You will have to work hard
- But the rewards are worth it

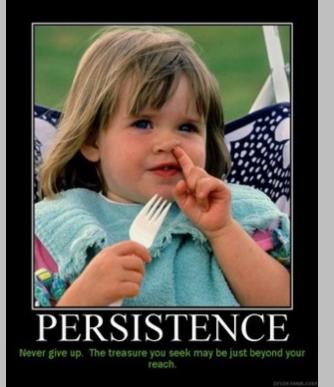


How can *you* get here? Or wherever you want to be

Step 3: Be persistent

More attempts = more chances for success



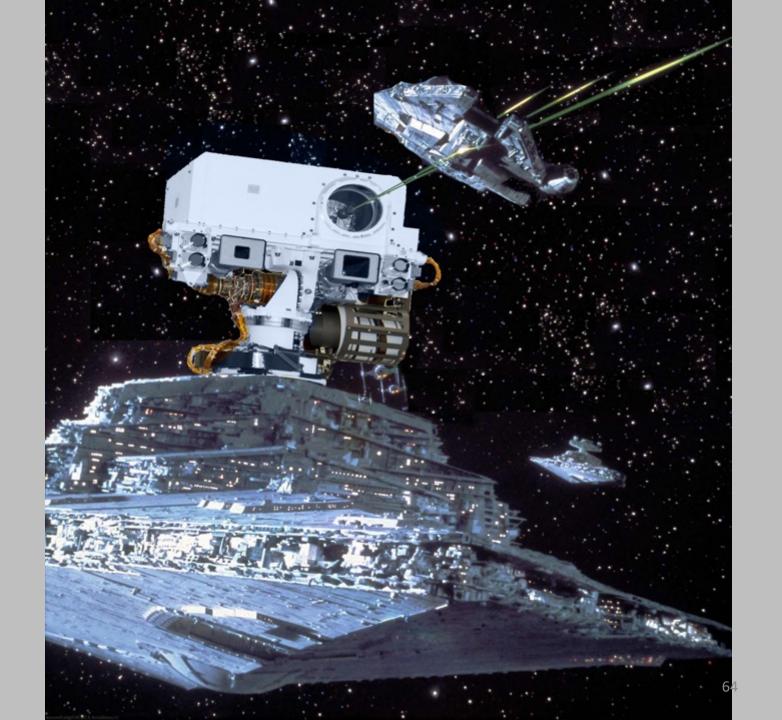




ChemRex

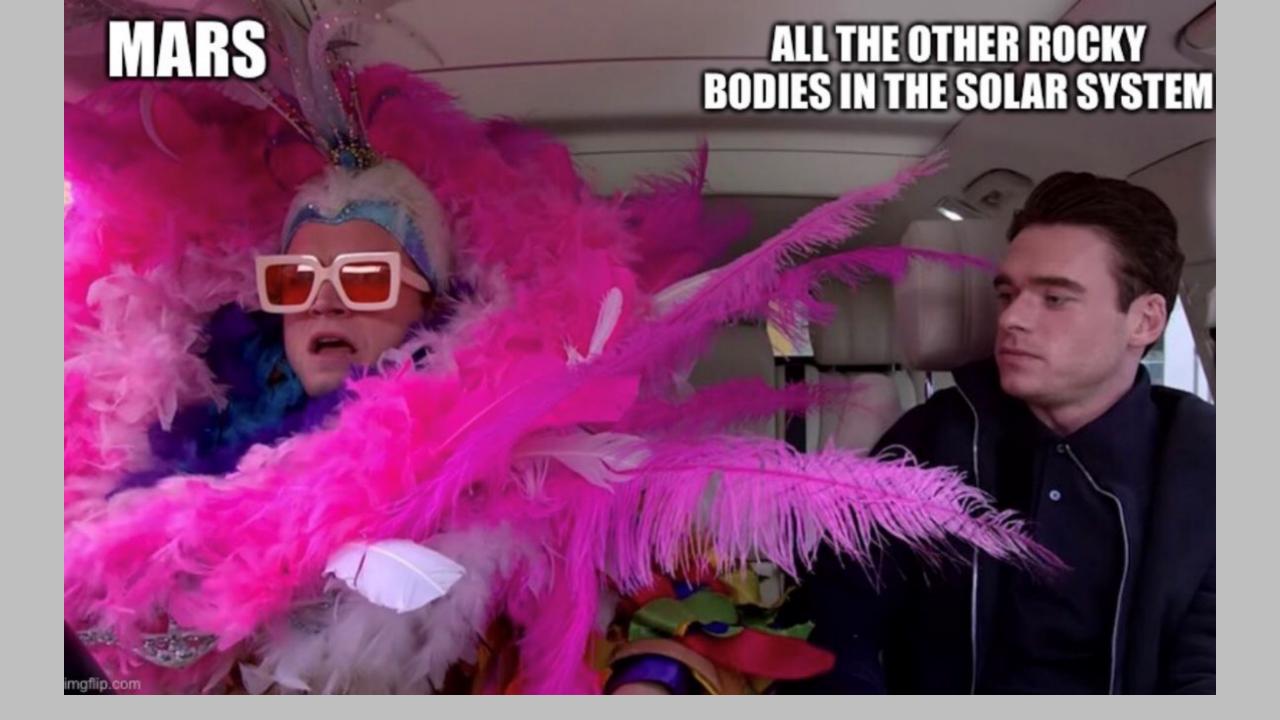


ChemDestroyer





French: "Why do people think that ChemCam will hurt cats?"



Lets play a game called.....

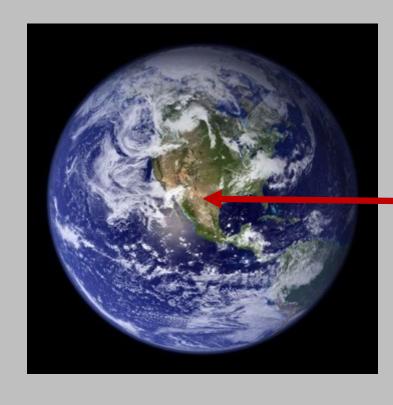
Mars or Earth?





Mars or Earth?





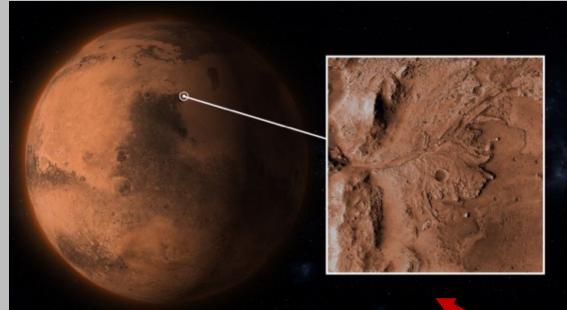
Shiprock, a volcanic peak sacred to the Navajos as Tse Bitai, the "Rock With Wings," rises from the surrounding desert in **New Mexico, USA, Earth**.

Image Credit: John Grabowska



Mars or Earth?

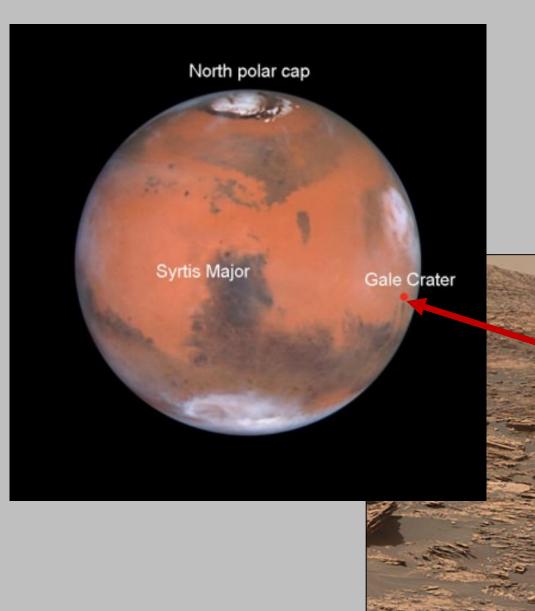




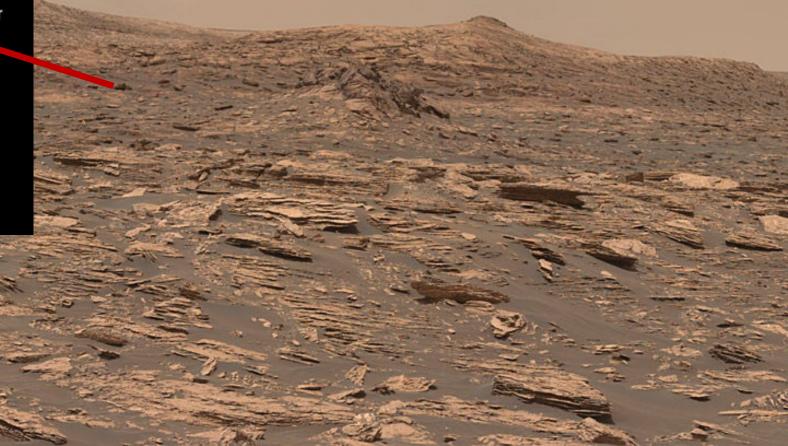
Perseverance landing site,
Jezero Crater,
Mars



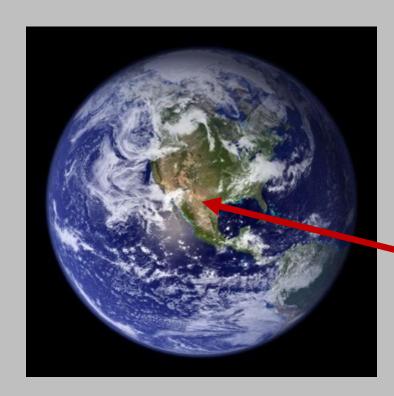




Vera Rubin Ridge, Gale Crater, Mars







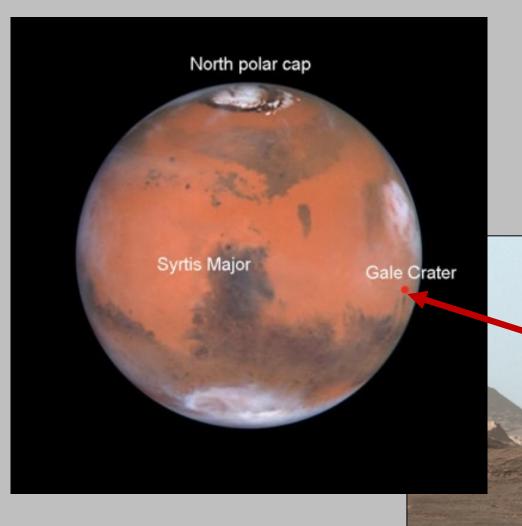
Shatter Cone: The recently discovered shatter cone exposure near **Santa Fe, New Mexico, USA, Earth**.

• Formed by shock waves from an ancient meteorite impact

Photo credit: Geoffrey Notkin, copyright Aerolite Meteorites

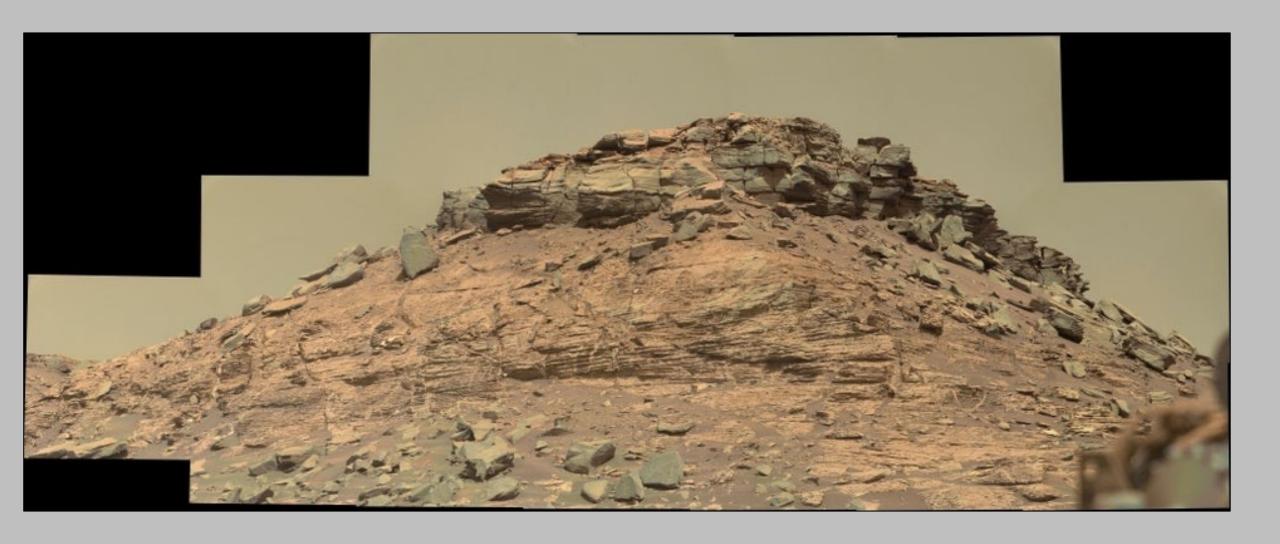


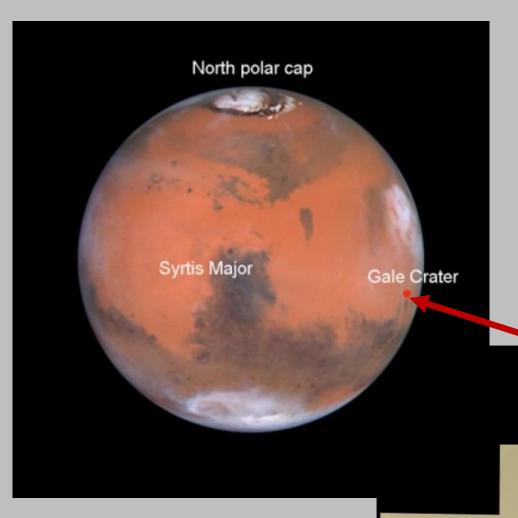




Mount Sharp, Gale Grater, Mars

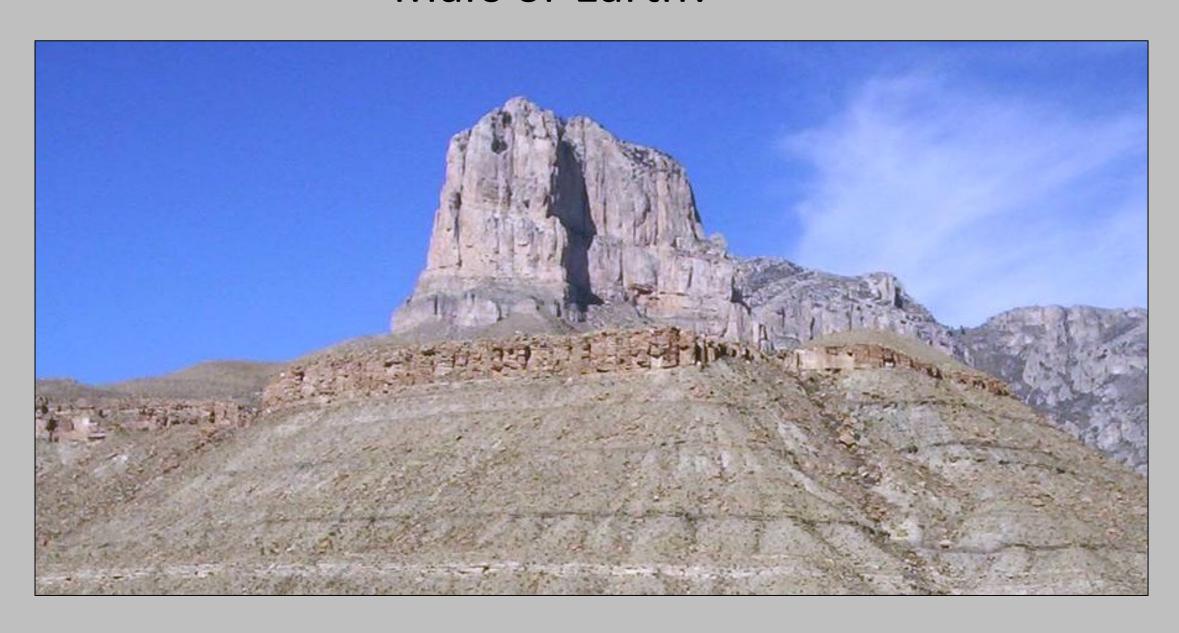






Tower butte, Gale Crater, Mars



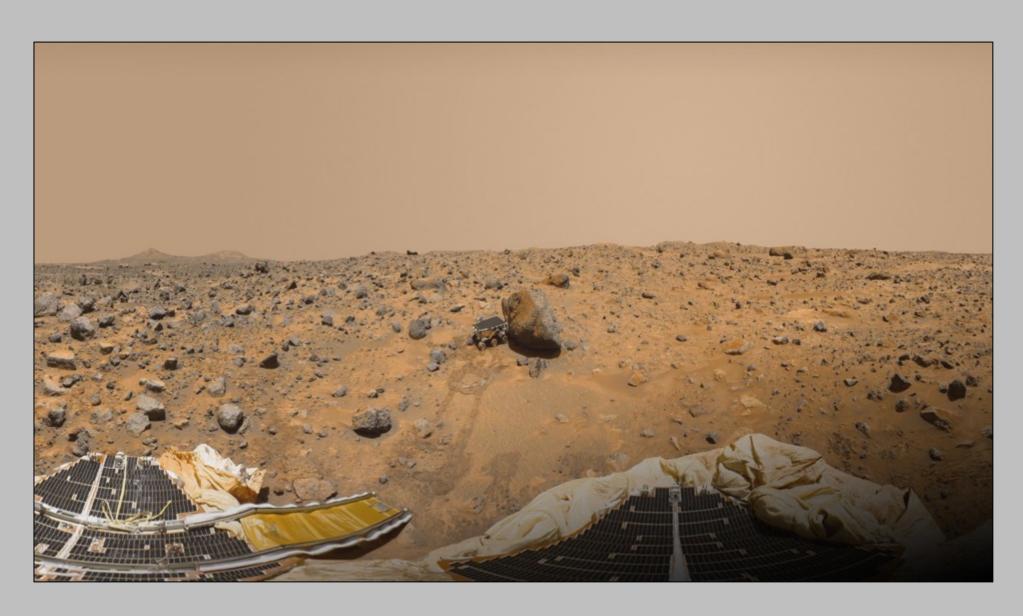




El Capitan, Texas, USA, Earth

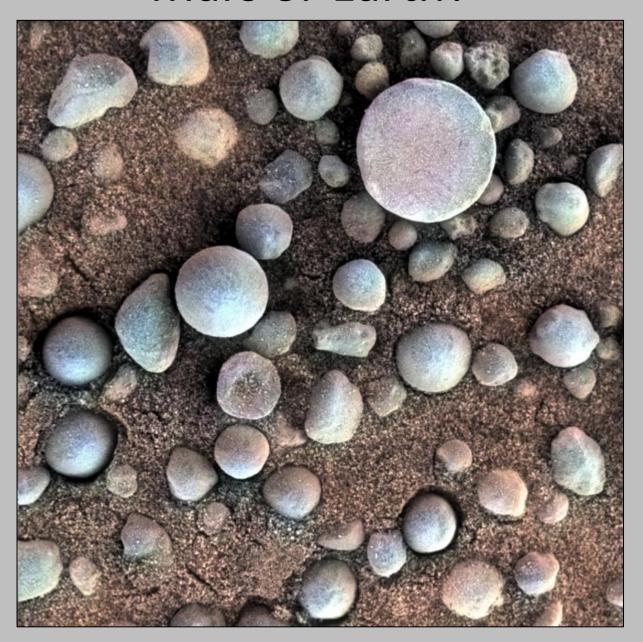


Image credit: Roc Doc Travel





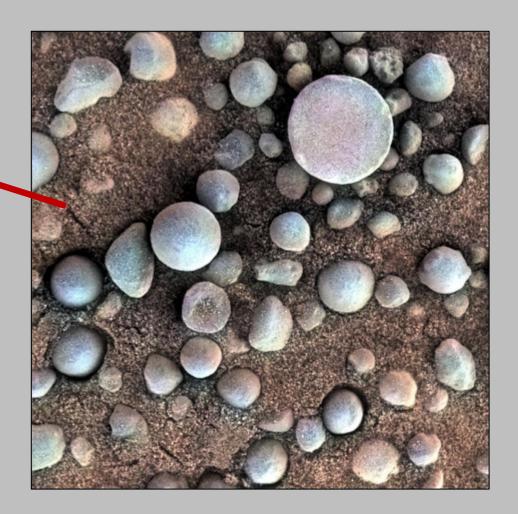
Pathfinder landing site, Ares Vallis, Chryse Planitia, Mars





Fram Carter, Meridiani Planum, Mars

Martian spherules (also known as blueberries) are the similar to hematite concretions found on earth that are formed when minerals precipitate from flowing groundwater.





Sechura Desert, Peru, Earth





Image credit: Smithsonian

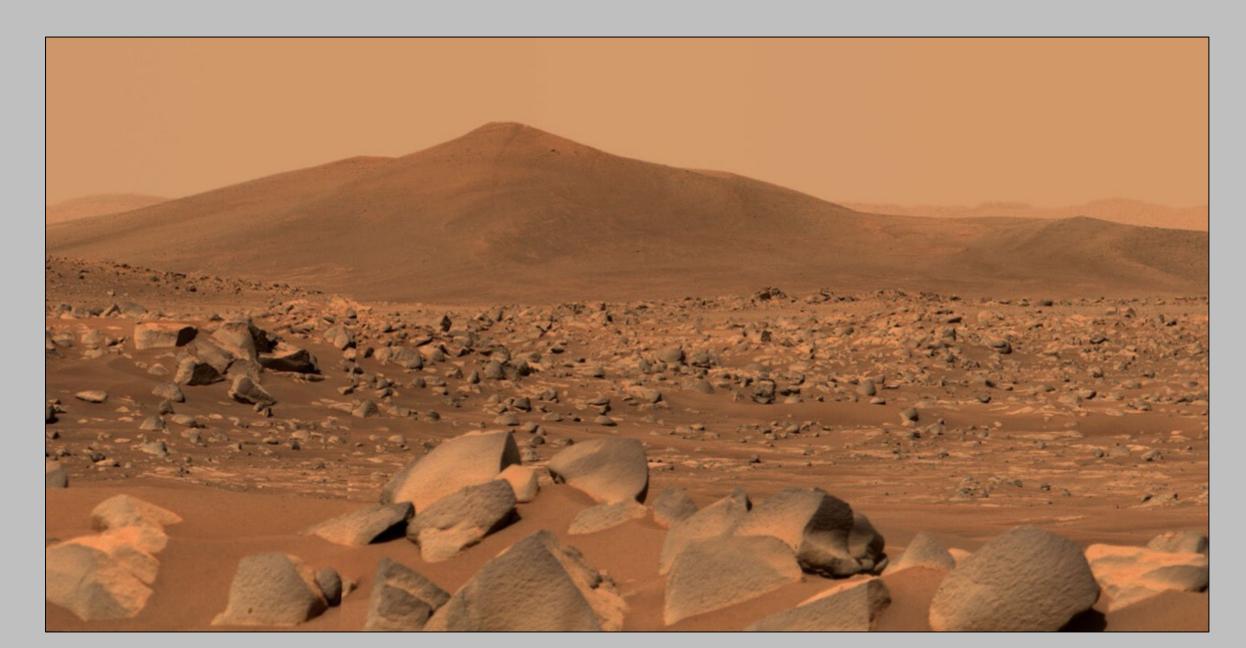


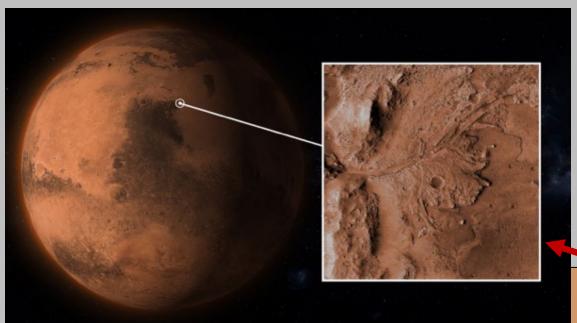
West Sahara desert, North Africa, Earth





Image credit: One Earth

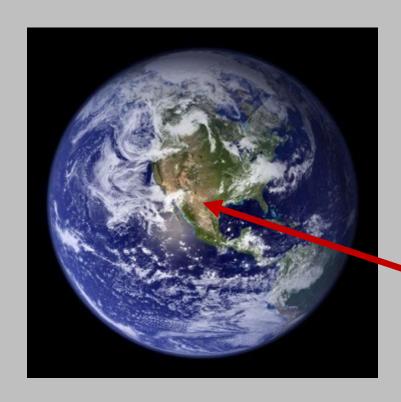




Jezero Crater, Mars



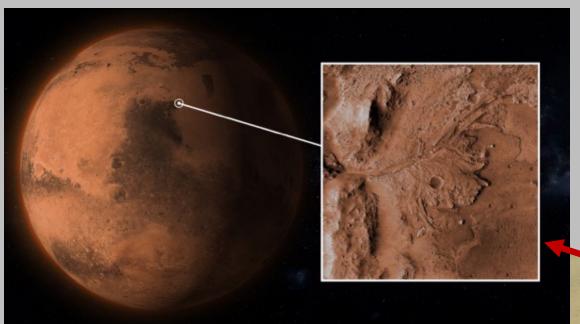




Walnut Canyon, Los Alamos, New Mexico, USA, Earth







Jezero Crater, Mars





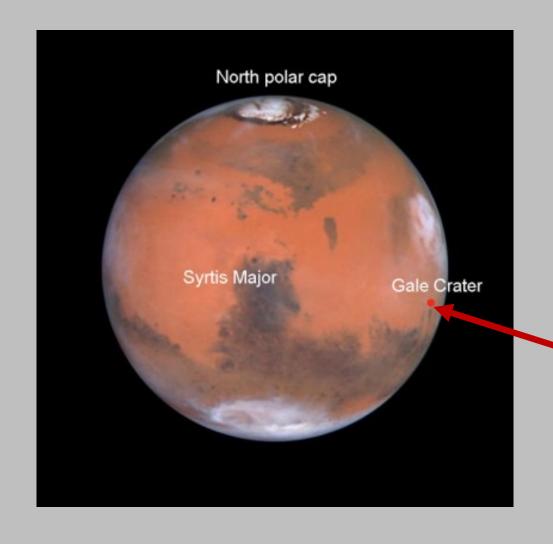


Bisti Badlands in **New Mexico, USA, Earth**

Photo credit: Jim Ekstrand







Gale Crater, Mars





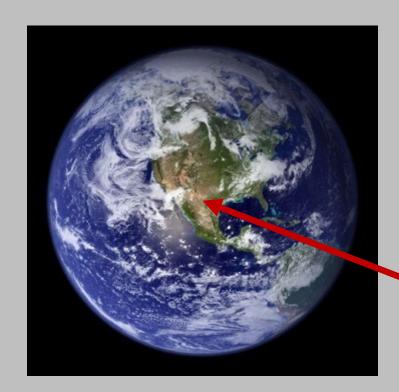
Sojourner Opportunity Curiosity Spirit

Meridiani Planum, Mars

These are Opportunity rover's tracks as it makes its way across the Martian surface





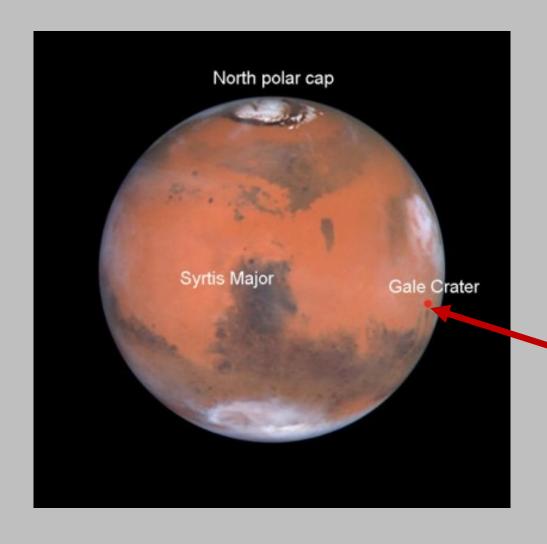


Meteor crater, Winslow, Arizona, USA, Earth



Image credit: Britannica





Gale Crater, Mars







New Mexico, USA, Earth San Juan Basin, Valley of Dreams, Badlands, Ah-shi-sle-pah Wash

Image credit: Getty





Columbia Hills, Gusev Crater, Mars



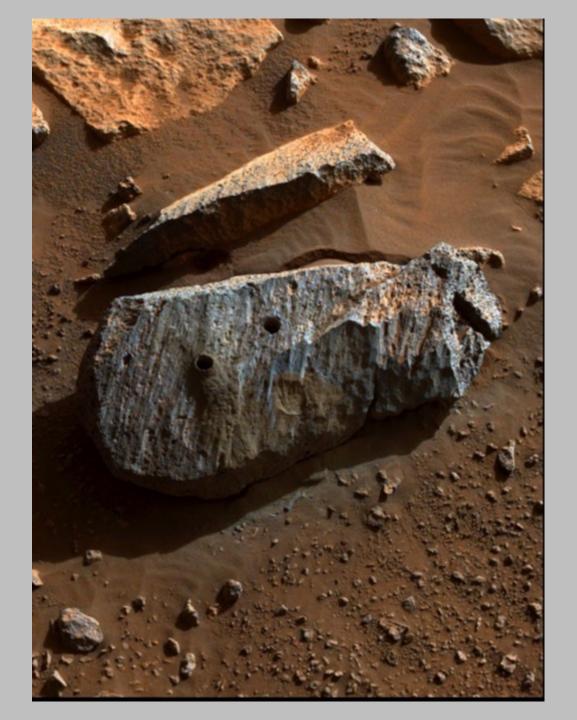






Bonneville, Gusev Crater, Mars







First two successful
Drills and abrasion for
Perseverance rover,
Jezero Crater, Mars



Backup

links

Mars timeline https://youtu.be/AP6hg92bPEo

Supercam https://youtu.be/a6HOap-3fiQ

https://youtu.be/shTb5MHt1to

https://youtu.be/OLqBo8CoS7Q

Driving sounds https://youtu.be/EiQvlM4taBQ

Sending rover to mars https://youtu.be/gYJsMBabjVY

Landing https://youtu.be/cA8ar8vwpTs

EDL https://youtu.be/4czjS9h4Fpg

Phoning home: https://youtu.be/2t7p08hcQzs

Volcanoes https://youtu.be/Cww3yVQpcjY

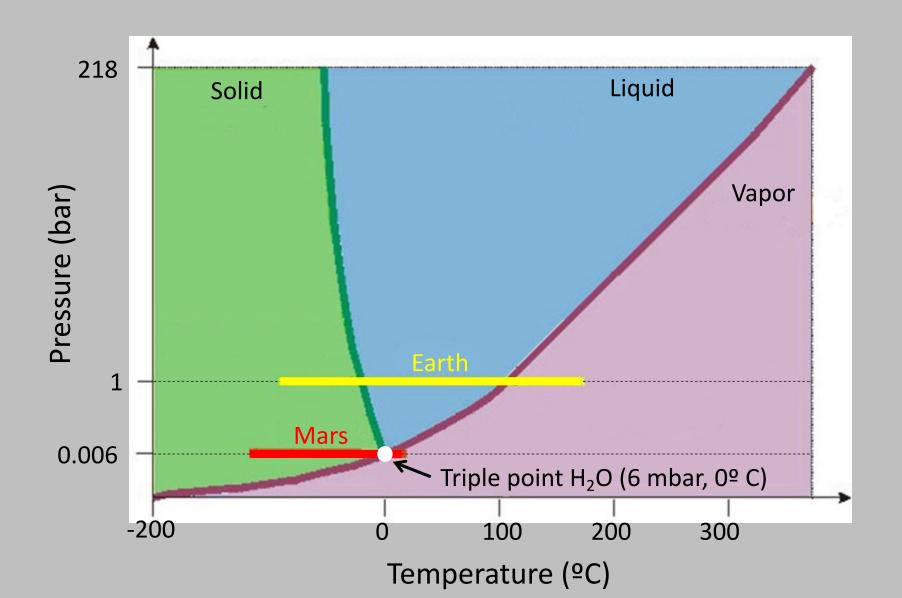
Driving on mars https://youtu.be/e6vzjNkDB5k

Mic https://youtu.be/uLWaDHfsFso

Ginny https://youtu.be/qVKZIZjaMs0

All https://youtu.be/rJsA061awV4

Water diagram



NASA within the US Federal Budget Pie Chart

